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ABSTRACT

The overall goal of this report is to help university administrators assess what computer-aided university planning can and cannot do for them and to arouse their interest in the application of system analysis, simulation, and computer models to university planning. The report is limited to analysis of selected examples of computer oriented applications to university planning. Brief and relatively nontechnical descriptions of the programs are presented for the benefit of busy administrators and for planners who wish to inform themselves about methods, tools, and approaches to solving institutional problems. This document was previously announced as ED 041 188. (Author/HS)

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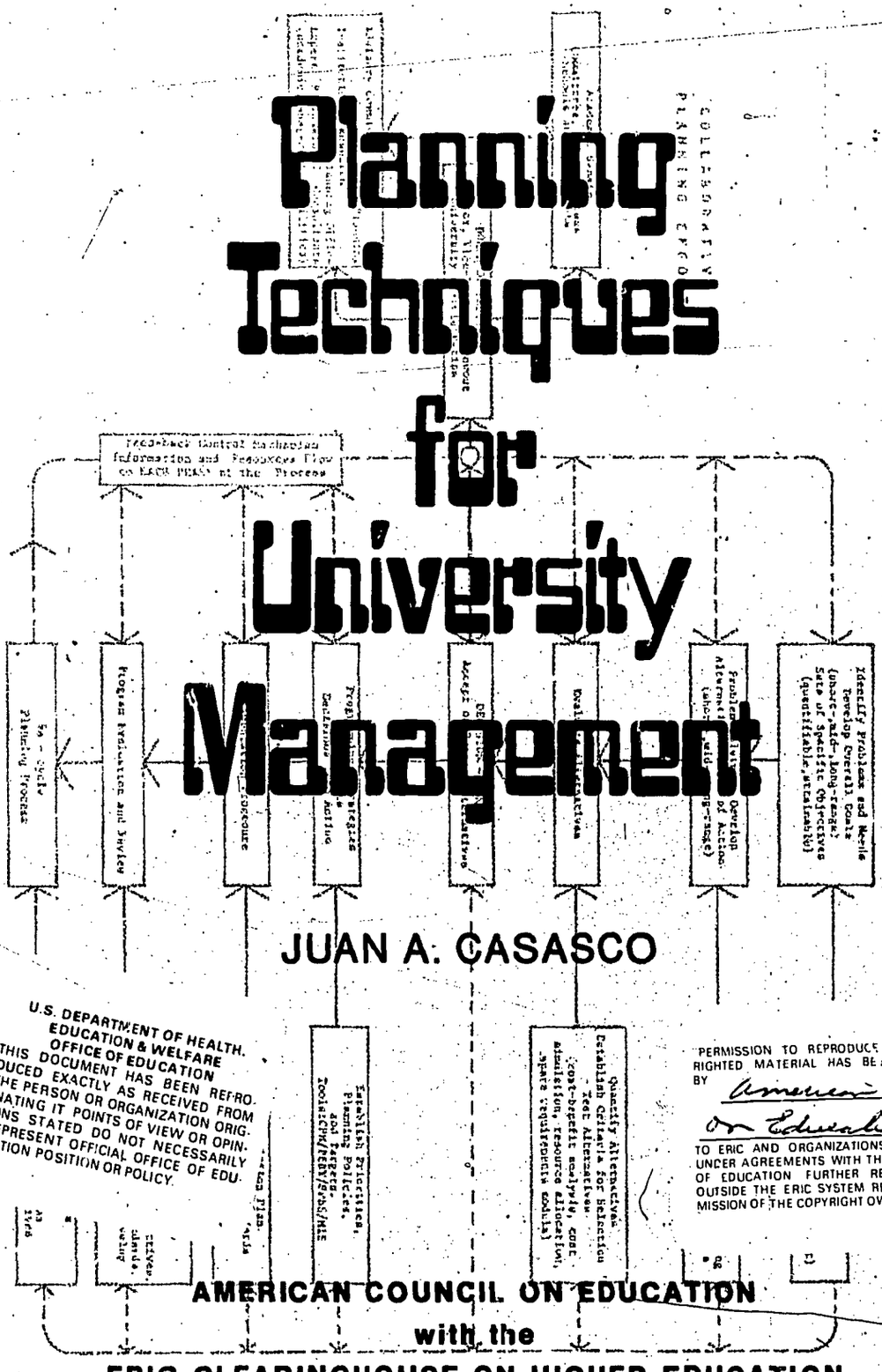
Planning Techniques for University Management



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FOREWORD

Juan Casasco's report serves a simple but useful function. It permits the academic administrator to find out what progress has been made, on a variety of campuses, in using computers and system analysis in academic administration. Millions of dollars have been spent on research, experimentation, model-building, and analysis. Most of the literature reporting it is incomprehensible to all but a few administrators. Reports are in many cases scattered among a patchwork of agencies and sponsors; some are out of print.

Professor Casasco, with the generous assistance of the Educational Facilities Laboratories, has prepared a concise outline of representative work done in the field through about the spring of 1970. This summary, like any such work in this field, will soon be out-of-date. But the administrator who wants to know what has been done or thought can start here. If his needs or his curosity impel him, the references may be followed to their source.

Publication of this report has been materially assisted by a supplementary grant to the American Council on Education by the Educational Facilities Laboratories. In addition, the cooperation of the ERIC Clearinghouse on Higher Education in preparing copy for duplication is gratefully acknowledged. Camille Jones of the Council's Publications Division deserves special thanks for supervision of production. Ann Caffrey assisted materially in preparing the text for production and made many useful suggestions.

John Caffrey, *Director*
Commission on Administrative Affairs

PREFACE

University planning concepts and methods and the applications of currently or recently available computer models and programs for planning are the subject of this report. It is an initial attempt to probe into the problems connected with university planning within the context of overall institutional development.

Brief and relatively non-technical descriptions of selected programs are presented for the benefit of busy administrators and for planners who wish to inform themselves about methods, tools, and approaches to solving institutional problems.

The report is limited to analysis of selected examples of computer oriented applications to university planning. It is not an all-inclusive survey of the state of the art. The sample was drawn from colleges and universities of various sizes, resource availability, and geographic location and from management and architectural consulting firms in order to obtain a proper mix of meaningful experiences. The relevance of the contribution to the state of the art has been the criterion of their selection. Some of the computer models and programs were selected because of their direct applicability to university facilities planning. Others, although currently operational only in such areas as architecture, management, or financial planning, were considered transferable and adaptable to university planning in other areas.

The overall goal of this report is to help university administrators assess what computer-aided university planning can and cannot do for them and to arouse their interest in the application of system analysis, simulation, and computer models to university planning. If this goal is achieved—if it contributes toward efficiency in university management—the time and effort involved in producing this report will have been worthwhile.

The author gratefully acknowledges the many individuals and institutions which contributed in a variety of ways to make this study possible, particularly those research analysts and institutional planners, authors of the computer models and techniques reviewed in the study, and those who contributed their time and thought in interviews, and who supplied reports and other valuable research material.

To Alan C. Green of Educational Facilities Laboratories the author owes a special debt for his untiring cooperation and critical comments throughout the study.

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INTRODUCTION

Universities are becoming ever more complex and multifunctional. This fact emphasizes the need for a systematic approach to institutional planning which is capable of treating a total program, rather than utilizing elaborate methods to tackle a fragment of the problem. Next year's budget, a new dormitory, student enrollment or the acquisition of new faculty—all are critical concerns of university administrators, planners, and faculty. These problems can no longer be viewed in isolation from one another without running the risk of considerably distorting the goals of the university.

The need for the development of a "total approach"—hazardous as this may seem—becomes evident as one observes how university management has met the problems of growth with improvised decisions based on inadequate information. Such improvisation has often resulted in campus disarray and inefficiency of operation.

Before the computer the best solutions were reached by intuition and by random evaluation of possible alternatives. Most decisions were made—and too many still are made—on the basis of limited information, unsupported theories, and scanty empirical analysis. Administrators are increasingly asked to substantiate budget requests and to provide detailed accounts of their programs. Under these circumstances, intuition alone will not suffice to justify their decisions as to the most efficient allocations of university resources. Enlightened and well-informed university administrators are acutely aware of the need for more rational and systematic approaches.

What is needed is a conceptual framework within which the complex interrelationships of a university's operations can be viewed as a coherent system. Systems planning provides an approach whereby key university problems can be stated in a form appropriate for mathematical analysis. These computational techniques allow a university system to be viewed as a set of interrelated activities that can be linked coherently to attain preestablished sets of objectives.

When considered as systems components, such individual sectors as the academic, management, and physical plant can be regarded as a collection of interacting elements, each related to a specific aspect or operation of the institution. Within the framework of this conceptual approach, this study examines how selected institutions of higher education approach their own developmental planning.

First, an attempt is made to uncover areas or subcomponents of the university systems where meaningful contributions to university planning are being made. Second, an analytical evaluation is conducted to determine the level of comprehensiveness of the case studies reviewed. Third, their scope, current status, and degree of operativeness are described. These findings are shown in a comparative matrix (pp. 71-73) which permits an evaluation of

the frequency of occurrence and identifies the lack of certain key elements of university planning.

Each institution has its unique problems, resources, and requirements; thus no universal formula, applicable to all possible cases, can be derived. However, the findings of this study point to possible avenues by which an institution can approach its planning problems in the light of the experiences of other institutions.

The reader, be he administrator, campus planner, or member of a committee entrusted with the responsibility of developing policy guidelines for institutional development, will have to draw his own set of inferences as to how his institution can apply the methods and approaches presented in this report.

This research has unearthed no universal or "total" planning system capable of operation under any set of variables and parameters. A total system is perhaps a desirable planning goal but hardly an attainable one. It is possible, however, that a minimum set of subsystems or components could be devised by individual institutions as the best mix of planning elements that would satisfy their planning and operational needs. Perhaps the main contributions of all the studies examined here are the thinking processes, analytical approaches, and simulation techniques that provide meaningful information for rational decision making.

The information for this study has been collected from personal interviews, correspondence, and review of published and unpublished material. The literature search was not intended to be historical or exhaustive since only recent studies were the concern of this analysis.*

From the interviews, it became evident that while information in certain subareas may not be readily available, it is, nonetheless, considered highly relevant and and necessary to planners and administrators. An attempt was made to single out several of these gaps with the expectation that studies will soon be undertaken; if information was available but not included in the report, it is hoped that it will appear in future reports that will update this study.

* For bibliographies of previous studies see:

"A Selected Bibliography on Important Aspects of University Planning," by Robert W. Chamberlin. New York: Educational Facilities Laboratory, June 26, 1967.

"Campus and Facilities Planning in Higher Education. An Annotated Bibliography," by Philip S. Phelon. Albany, New York: The State University of New York, May 1968.

I

UNIVERSITY PLANNING

A. The Need for Planning

Orderly growth and efficient resource allocation in universities requires a systematic and coherent way of planning ahead, by envisioning the scope and direction of institutional development. Although university administrators recognize the need for charting the future course of their institutions, planning is one of the least understood functions of administration.

To bring the meaning and purpose of planning into clearer focus, one must ask such basic questions as:

What is "comprehensive planning"?
What is the "systems approach"?
How can comprehensive planning be applied to university planning?

Answers to these questions can be approached by defining these terms, by examining the scope of general systems theory and its applicability to institutional planning, and by discussing such component subsystems and tools as management, planning, resource allocation, and physical facilities. Rather than offer a ready-made formula applicable to a specific case, broad issues and the various approaches available to university planners will be examined.

Every university has its own unique planning requirements and operates under particular sets of constraints and resources. The reader will draw inferences and alter this broad, conceptual approach to fit the situation at his own institution.

B. Comprehensive Planning

University planning should encompass all interrelated university activities—academic, budgetary, and facilities. There is, however, much confusion regarding "overall goals," "specific objectives," and "scope of planning." Planning has been loosely interpreted as "campus planning," "physical facilities," or "next year's budget." Its interpretation has ranged from a set of subjective, broad, and philosophical institutional goals to a detailed data management system. In light of the difficulties encountered in defining planning, its function and scope, the following definition is offered for the purposes of this report:

> Planning is the process by which a university defines its overall goals and specific objectives and devises the means of attaining them.
>
> Comprehensive planning is a coordinative device; a distinctive approach and technique to make operative a complex of separate, specialized activities. Every element in the complex is related socially, economically, and physically.

One of the advantages of the comprehensive planning approach is that it increases one's knowledge of how one element in the complex interacts with others, and how it is related to the structure of the organization as a whole and to the outside world.

Comprehensive planning, within the context of university management, draws from such diverse areas as operations research, management sciences, systems engineering, architecture, physical planning, and the behavioral sciences. It must deal with a wide variety of variables, subjective or quantifiable. It must yield a set of alternative plans for use within the time limits developed by the institution.

A comprehensive plan must be:

1. Operational; i.e., capable of being put into effect.
2. Sufficiently lucid to enable the decision-makers to grasp its purpose, scope, and content so that it can be effectuated.
3. Sufficiently developed so that administrative assistants can implement the plan.
4. Designed with an awareness of the availability of current and potential resources, of the requirements of the institution as a whole, and of the possibility of conflicts among its component parts.
5. Capable of undergoing periodic review and revision to adjust to inevitable changes.
6. Endorsed by a determined commitment by the administration of the institution.

The terms "comprehensive planning" and the "systems approach" are equivalent concepts for the purposes of this study. Both terms are assumed to connote:

> An integration of interacting component elements or subsystems designed to effectuate collectively a preestablished planning function.

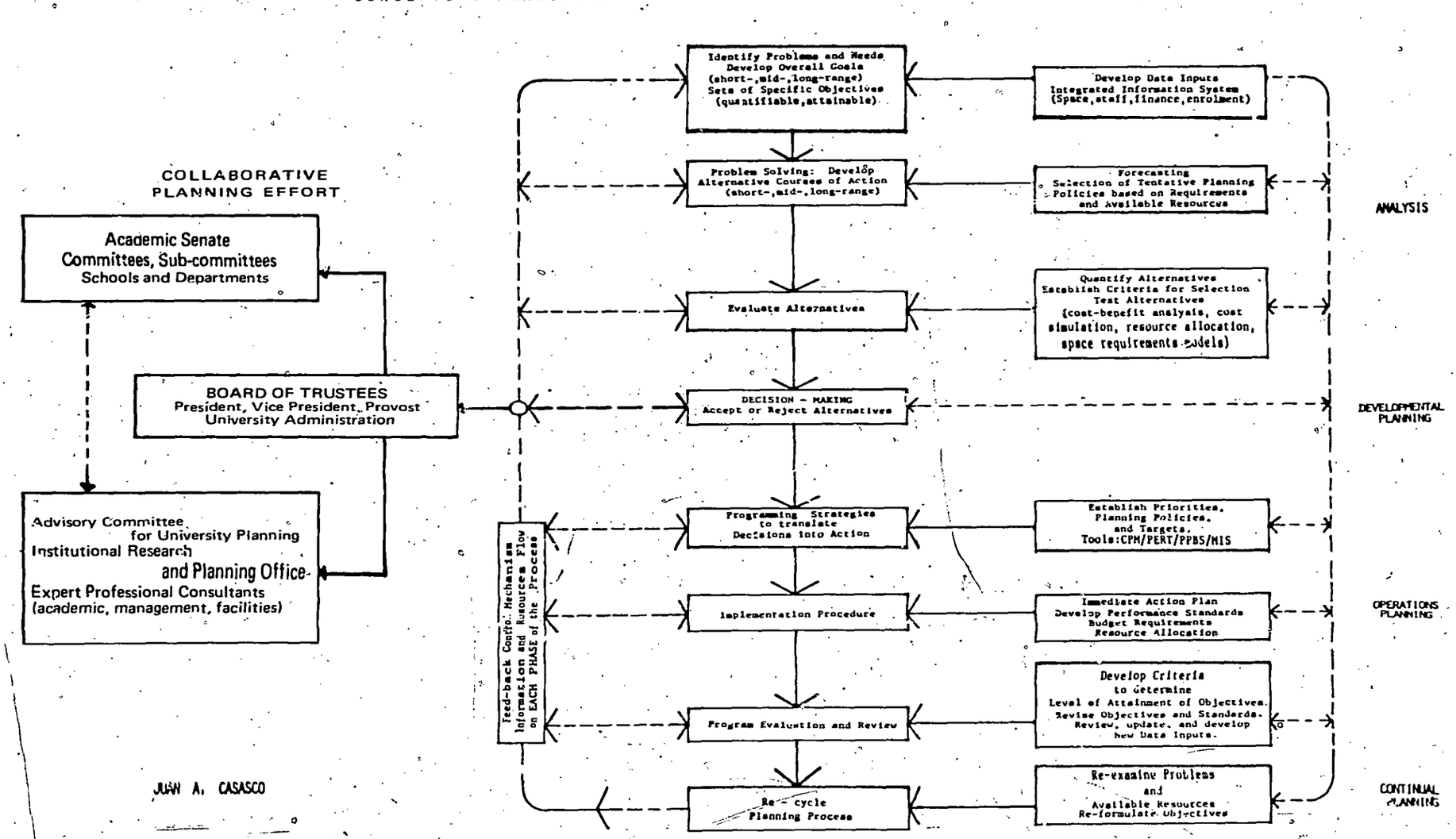
C. A Methodology for University Planning: Conceptual Framework

The methodological approach to university planning is borrowed from defense, corporate, and urban planning techniques.

It provides guidelines on how to plan and indicates how tools, such as simulation models and management information systems, can be used in the university's planning process.

A sequence of eight sets of main tasks and sub-tasks, and their linkages with the planning process is illustrated in the Figure opposite. The conceptual framework is purposely normative, and the diagram shows how (ideally) a university would carry out a planning task.

A METHODOLOGY FOR UNIVERSITY PLANNING:
CONCEPTUAL FRAMEWORK



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1. The first main task is that of the identification of problems and needs, and the development of sets of overall goals and specific objectives for institutional development. Clear distinction must be made between *goals*, as general statements of ideals expressed in abstract terms, and *objectives*, as specific aims, measurable and achievable, which may require reformulation under given circumstances. Objectives are obtained by applying preestablished standards to a set of overall goals.

   To perform this task, data inputs must be developed to provide meaningful information on facilities, academic, financial, and administrative activities in space and time.

   The output of this task and its corresponding sub-task should be (1) a set of quantifiable, realistic, and achievable objectives and (2) tentative sets of priorities and targets which must be met in order to achieve these objectives.

2. The second task is that of the formulation of alternative courses of action to achieve the above objectives in short-, mid-, and long-range terms. The corresponding sub-task is the selection of tentative planning policies based on objectives, requirements, and resources available to the institution.

   The performance of both task and sub-task demand considerable effort, time, and commitment by the administration, faculty, and staff of the university. Trial and error *and* structured discussions by all groups concerned would be useful.

3. The third task is an evaluation of the alternatives in terms of the tentative priorities and targets. The analytical and forecasting techniques used in the case studies of this report are put into use. Cost benefit analysis, cost simulation, resource allocation, and space requirements models provide the necessary information for decision making. This task ends the *analysis phase* of the process.

4. Task four: The decision to select the alternative, which, in the light of objectives, policies, and resources, will result in the best possible performance within institutional constraints. This is the first stage of the decision-making process of institutional development and requires the collaborative efforts of faculty, management, and administration.

5. Task five: The formulation of programming strategies in order to translate planning decisions into action. The corresponding sub-task is the provision of tools to chart the most effective course. PERT and CPM make it possible to see the effects of selected courses of action and facilitate identification of possible bottlenecks and conflicts during the planning process. MIS and PPBS provide effective information for selecting implementation strategies.

6. Task six: Effecting the program through the institution's organization and behavior. The corresponding sub-task is that of devising an immediate action plan, and developing a set of performance standards with which to measure program achievements. Short- and mid-term budget requirements and resource allocation strategies can complement the implementation procedures.
7. Task seven: Program evaluation and review. As the institution's plan is being implemented, a series of checking devices is developed to evaluate the level of attainment of specified objectives. At this point, evaluation and review of attainment of specified objectives are undertaken. A feedback mechanism employed throughout the process would allow for identification of new data inputs required by the changing needs, resources, and forces affecting the institution. Operations planning encompasses previous tasks and terminates with program evaluation and review.
8. Task eight: The recycling of the planning process by close reexamination of problems (which often change by this stage of the process) and available resources. A new set of objectives may have to be developed to respond to these changes. The feedback mechanism operates throughout the process and serves as a continual planning device which responds to institutional changes.

In sum, the methodology utilizes:

a. A coherent set of objectives.
b. The development of an information system.
c. Synthesizing and strategizing the course of institutional development.

II

DEVELOPMENTS IN COMPUTER-ASSISTED UNIVERSITY PLANNING: TWENTY-ONE CASE STUDIES

Over forty models of various scope and degree of operativeness were reviewed. Of these, twenty-one were selected for their significance in terms of potential contributions to other institutions faced with similar problems. These were classified into two major groups: *operational* programs in planning, and *developmental* efforts.

The first category includes computer-assisted models or techniques which have gone beyond the research stage and are operational. The second includes those modeling efforts which are in the realm of institutional research, but which offer substantial possibilities for implementation. Each category is sub-divided into *comprehensive* and *specialized* programs.

Note that throughout the study the terms "comprehensive approach," "comprehensive planning," "systems approach," and "institutional systems planning," connote equivalent concepts. They all signify an *integrated* effort, combining administrative, facilities, and academic planning in institutions of higher education. The specialized programs are those limited to problem-solving in one area or subsystem of the institution's total system.

Review findings of the twenty-one case studies are presented in a comparative matrix with tables (pp. 72-73) which summarize the frequency of occurrence of planning elements, scope, and status of the studies.

Comprehensive Operational Programs

University of California
Michigan State University
University of Toronto–CAMPUS
University of Rochester
Peat, Marwick, Mitchell & Co.–SEARCH

REPORT: *The Development and Applications of a University Cost Simulation Model*, by George B. Weathersby (1967-68).

SUBJECT: Planning for large university systems.

INSTITUTION AND SPONSOR: University of California, Berkeley, California; Office of Analytical Studies of the Office of the Vice-President for Business and Finance.

SUMMARY:

OBJECTIVES:

1. To develop a computer simulation model as a decision-making tool for better resource allocation.
2. To apply systems analysis techniques already adapted to university planning:
   a. To adapt a planning programming budgeting system (PPBS) to a large university.
   b. To develop planning models that deal with academic, fiscal, and physical factors.
   c. To study cost effectiveness of alternate methods of utilizing resources.

METHOD:

1. INPUTS: Number of students by level and discipline and numerical parameters of academic plans.
2. OUTPUTS: Personnel required, academic and nonacademic types. Physical facilities -square feet by function and associated capital costs. Operating budget in all usual categories and program budget formats.
3. RESOURCES: Personnel, physical space and equipment, and general supporting costs.
4. COSTS:
   a. Instruction (faculty costs).
   b. Instructional support (support personnel, facilities, equipment, supplies).
   c. Organized research and activities (institutes, bureaus, centers, studies).
   d. Campus-wide administration-service functions (general administration, libraries, housing, student aid).
   e. Physical space and maintenance of operation.

The aggregate of these costs for any year provides the total annual university systems costs in terms of dollars, personnel, equipment, and physical facilities. Specific curriculum plans and educational policy, space requirements, salary scales, levels of support, and construction programs are parameterized and costed out. With these tools the consequences of long- and short-term alternatives can be estimated and evaluated.

5. PROGRAM CHARACTERISTICS:
   a. Language—FORTRAN IV implemented on IBM 7094, 360/65, and CDC 6400.
   b. Source deck—2500 cards and 10 subroutines.
   c. Data deck for one campus—800 cards.
6. MODELING PHYSICAL FACILITIES REQUIREMENTS:
   a. Data inputs: Physical space data from the Restudy Space Standards accepted by the Coordinating Council for Higher Education and the University of California.
   b. Method:
      1) Classification of non-residential facilities:

Classrooms	Organized Research
Class labs	Organized Activities
Research and Office	Library
Physical Education and Military Science	Other

2) Calculate total amount of assignable square feet (ASF) for each type required by a particular configuration of the university system. Compare each calculated ASF with corresponding ASF of the previous period. Model will calculate additional capital outlay needed to close the annual gap.

c. Output: The amount and operating costs of the physical space required by each discipline. Total space is broken down by classrooms, class-lab and research, and office ASF.

FINDINGS:

Model findings were validated by comparing simulated model forecasts of annual operating budgets from 1960-61 through 1966-67 with the actual budgets. Model predictions were reasonably close to the actual budgets, thus indicating that the simulation model is an accurate planning tool. Versions of the Model are operational for the Berkeley and LA campuses.

APPLICATIONS:

1. Quantitative analysis of the cost consequences of a four-quarter system (summer quarter operation). Two operation models were developed: Model 2, applicable to an expanding campus, and Model 3, applicable to a "mature" campus.
2. Determination of cost of faculty, staff, and facilities necessary to educate one student in a specific major and class in school, for one year.
3. Establishing minum course-size. Determination of savings resulting from eliminating all undergraduate classes of under ten and all graduate classes under five.

LIMITATIONS:

The model simply forecasts direct and opportunity costs. Estimates of benefits are left to the academicians and academic planners.

REPORT: *A Systems Model for Management, Planning and Resource Allocation in Institutions of Higher Education,** by H.F. Koenig (Principal Investigator), M.G. Keeney, and R. Zemach, (1968).

SUBJECT: Resource allocation for cost accounting, decision making and simulation.

INSTITUTION AND SPONSOR: Michigan State University, East Lansing, Michigan: National Science Foundation, Office of Economic and Manpower Studies.

SUMMARY:

OBJECTIVES:

To build a mathematical model of an educational institution that will provide the "logic" of information processing programs to aid university administrators in the allocation of resources.

SCOPE:

This model provides a logically consistent conceptual and theoretical framework for the design of computer-based management information systems to aid administrators at all levels of administration in cost analysis, resource allocations and budget negotiations. It provides the structure for a variety of simulation models designed to evaluate alternative allocation policies, changes in program requirements, enrollments, expansion programs, etc.

METHOD:

1. CONCEPT: The university is structured conceptually as a set of interconnected functional sectors or subsystems:
   a. Students,
   b. Production (academic and nonacademic),
   c. Resources (personnel and physical facilities),
   d. Administrative control.
2. MODEL: A state space model of the university as a system input-output process is constructed from a mathematical model approximating the dynamic behavioral characteristics of the student sector and "static" input-output models describing the allocation policies used in the production and resource sectors.

   The state vector in the resulting model includes the student population by field and level and the associated accumulated costs.
3. THE INPUT VECTORS INCLUDE:
   a. The number of new students (by field and level),
   b. The number of units of outside services (by type),
   c. The number of fellowships and scholarships (by field and level),
   d. Unit cost of input manpower (by classification),
   e. The unit costs of input environmental facilities (by type).
4. THE OUTPUT OR RESPONSE VECTORS INCLUDE:
   a. The number of units of developed manpower (by field and level),
   b. Number of units of input manpower (by classification),
   c. Number of units of various types of environmental facilities (by type),
   d. The unit cost of producing the developed manpower (by field and level).

*A follow-up on a previous study by the same authors: **State-Space Models of Educational Institutions,** Division of Engineering Research, Michigan State University, East Lansing, Michigan, 1967. See abstract (same title) in Proceedings of WICHE-ACE Higher Education Management Information Systems Seminar, April 1969.

5. PROTOTYPES: A series of prototype computer programs were developed based on the structure of the model to illustrate some of the practical applications of the model.

FINDINGS:

1. COMPUTER APPLICATION OF THE MODEL–the theoretical model was tested using three sets of data files from MSU records:
   a. Student Master Files processed by the program STUVEC.
   b. Class Card File processed by the program CLASCARD.
   c. Faculty Class Schedule.
2. OPERATIONAL COMPUTER PROGRAMS:
   a. MSUSIM 1: A remote terminal program developed mainly to facilitate man-machine interaction (MSU administrators and a GE-265 computer system). This program is postable, time-sharing, and affords users multiple access through teletype from different locations on campus to computer systems located in various cities.
   b. MSUSIM 2: A simulation program. Administrators using MSUSIM 1 instructions and the user's manual can construct an experiment, write and keypunch the simulation program and obtain results in about twenty hours.

APPLICATIONS:

A wide variety of conceptual tools and computer simulation programs to aid in decision making at all levels of administration, including:

1. Resource allocation aids.
2. Program planning and budgeting procedures.
3. Vehicle of communication for budget negotiations.
4. Project resource requirements and costs associated with changing enrollments, curriculum requirements, allocation policies.
5. Incremental cost studies.

LIMITATIONS:

A *de novo* implementation of the total system model as a computer simulation, with all the attendant problems of data acquisition and processing and computer input-output format, is very costly and may be disappointing in the actual capability it provides. Since the resource allocation process is distributed through a hierarchy of administration, effective application requires understanding, acceptance, and implementation at all levels of decision making.

Since a resource allocation model is concerned only with the flow of goods and services and their associated unit prices, quality of education and academic goals cannot be considered.

REPORT: *Comprehensive Analytical Methods for Planning in University Systems (CAMPUS)*, by Richard W. Judy, Jack B. Levine, et al. (1965-present).

SUBJECT: Computer models and management systems for university, college and health sciences education resource planning.

INSTITUTIONS AND SPONSORS: The Systems Research Group, Toronto, Ontario, Canada and The Institute for Quantitative Analysis of Social and Economic Policy, University of Toronto, Toronto, Ontario, Canada.

Sponsors:

- The Bladen Commission on the Financing of Higher Education
- The University of Toronto
- The Donner Foundation
- The Senior Coordinating Committee for Health Sciences Education in the Province of Ontario
- The Health Sciences Schools of the University of Toronto
- The Ontario Department of Education
- The Ford Foundation

SUMMARY:

OBJECTIVES:

To provide university decision-makers with information about the resource requirements of alternative programs and sets of system parameters. The model seeks to initiate or simulate interaction of important activity levels, uncontrollable variables, system parameters, and resource requirements in the university system; to improve the efficiency of resource allocation and raise the quality of planning.

1. To assess the feasibility of a systems simulation approach to the solution of university problems.
2. To determine the availability of data required to build the model.
3. To investigate the susceptibility of these data to methods of statistical analysis.
4. To determine the facets of university simulation and the difficulties of modeling them.
5. To build operating CAMPUS simulation models for college, a university, and a health sciences educational complex.

SCOPE:

CAMPUS was originally developed in 1965 to model the undergraduate structural activities within the College of Arts and Science at the University of Toronto. Since then, CAMPUS has been extended to model a large university, a health sciences educational complex, and a group of junior colleges.

METHOD:

The model accepts specification of various activity levels, system parameters, and uncontrollable variables (from the decision-maker). With the aid of a computer, it then calculates estimates of quantities of resources required to accomplish the specified program.

1. CAMPUS TOOLS:

   a. Program planning and budgeting system.
   b. Integrated information system.

   The instructional workload of each department for each simulated year is determined; resources required to handle that workload are calculated. To do this, the model is divided into four main sections:

   a. Enrollment formulation.
   b. Resource loading.
   c. Space requirements.
   d. Budgetary calculations.

2. SPACE REQUIREMENTS: Instruction, faculty offices, and administration space requirements are computed from the resource loading sector. Space standards are derived from planning factors set up by the Superintendent's office. Data on the type and amount of current space inadequacies are obtained by comparing the inventory of existing facilities with space requirements computed by this section of the model. Estimates are made of the costs of satisfying space demands by applying historical construction cost data for various types of spaces and indices of local building costs.

3. PARAMETERS: Conceptual specifications of the model are developed by describing system interrelations in mathematical terms. Parameters are established by:
   a. Estimation of existing or past values; e.g., statistical estimation or survey and interview methods.
   b. Forecasts of future values; e.g., future building costs, site preparation costs, non-academic wages and salaries, book costs, parking requirements.
   c. Specifications by decision; e.g., teaching load per staff member in various departments, staff-student ratios, common room space per student, and office equipment allocation per staff member.
   d. Specification for experimental purposes; e.g., examination of the impact of possible changes in various system parameters upon resource requirements; learning the consequences of a hypothetical rise in staff salaries over a certain period of time.

4. DEVELOPMENT OF ACTIVITY LEVELS: Model users may take two different approaches to determine activity levels. Both can be accommodated by CAMPUS.
   a. The "*student sovereignty*" *approach*, whereby the university tries to satisfy the demands of applicants to enroll in different courses.
   b. A *manpower planning approach*, whereby the university determines the proportional distribution of graduates among courses. The same approach could be used to establish levels of research efforts among different disciplines.

FINDINGS:

1. EXPANSION: CAMPUS was further developed and applied to the expansion and restructuring of the Faculty of Medicine.* Several basic simulation models have been designed and made operational:

   UGEDUC – Undergraduate education model.
   TRAINEE – Special training model.
   STAFF – Medial staff model.
   CIRCUS – Calculation of indirect resources and conversion to unit staff.
   PRIMER – Patient record information for education requirements.
   CIPHER – Calculations of patient and hospital education resources.

2. REMOTE CAMPUS: In order to apply the techniques of CAMPUS to smaller colleges that are facing periods of rapid growth and capital expansion, Remote CAMPUS has been developed. Briefly, it is a system that allows the college to communicate via a slow-speed terminal with a large central computer that stores the bulk of its data base and its version of the simulation model. Using an English language experimental control system, the user (a non-computer staff man) can direct the model to carry out a wide range of experiments. The results of these experiments are transmitted back to him via the terminal.

   Remote CAMPUS is now operational in three colleges in Ontario; it is presently being extended to 17 others in Ontario, and in addition to a number of colleges in the U.S.

APPLICATIONS:

The cost and time required to implement the CAMPUS system depends on the size and complexity of the institution being modelled.

1. SMALL COLLEGE APPLICATION: A college with an enrollment of up to 5,000 could be modelled using Remote CAMPUS in six months or less. A large-scale computer would not be needed. One full-time staff member could maintain the system and help others in the college formulate problems and interpret the results of the analyses.

2. LARGE UNIVERSITY APPLICATION: A large university of 30,000 students would require a computer equivalent to an IBM 360/65; the project would take some eighteen months to set up. A full-scale office of institutional research with appropriate computer programming back-up would be required to implement and maintain the system.

*Computers and Systems Analysis in Educational Planning by John Walter and R. Sadena. Mimeo from Health Sciences Functional Planning Unit, University of Toronto, Toronto, Ontario, Canada, June 1968.

REPORT: *Planning for the Development of the University of Rochester River Campus.* Thomas R. Mason, Director of Planning and Institutional Studies (1965-68).*

SUBJECT: Systematic program planning model.

INSTITUTION: University of Rochester, Rochester, New York.

SUMMARY:

OBJECTIVES:

1. To provide information to determine detailed space requirements of the academic departments for the 1975 policy levels for faculty, graduate, and undergraduate students.
2. To provide a basis for a continuing system of operating budget, space projections, and computer class scheduling systems.

SCOPE:

Resource allocation is achieved by integrating academic planning, facilities planning and cost evaluation functions. The entire process involves faculty, administration, and consultants under the coordination of the Office of Planning and Institutional Studies. Because the costly and enduring commitments involved in capital facilities demand long-range thinking, facilities planning constitutes a basis for organizing the planning effort.

METHOD:

River Campus colleges participated in an "Institutional Program Planning Study." Each academic department presented a plan for curriculum development based on an existing faculty plan. Ten-year projections were developed for:

1. Anticipated changes in course offerings.
2. Instructional methods (preferred class section sizes, weekly class meeting hours, type of facility).
3. Faculty instruction loads.

A computer program was developed to estimate course enrollments within the framework of proposed curriculum development. These data were used to compute contact hour, student contact hour, class size, and teaching load analysis for each department.

1. Simulation Model of University Instructional Program:
   a. Variable: Student input.
   b. Policy variables:
      1) Faculty teaching load.
      2) Class contact hours/FTE teaching staff.
      3) Alternative class section size.
      4) Average class section size.
   c. Parameters:
      1) Course enrollment.
      2) Rates by level of course.
      3) Student contact hours/course enrollment.
      4) Weekly class section hours.

*Affiliated with the University of Rochester until October 1968, Mr. Mason is now on the staff of the University of Colorado, Boulder, Colorado.

d. Output:

1) Facilities and space requirement estimates were produced for 1970 and 1975 for instructional, office, research, and service facilities. The planning model provided programming data used to plan new buildings and to assign existing building space over a seven- to ten-year period. The planning office prepared an outline program of space requirements for each project from the model data, frequently with analysis of varying assumptions. These data provided bases from which to decide the basic scope and content of the project. With the faculty and staff of the departments involved, the Planning Office prepared a detailed building program.

2) Architectural design and the building program are frequently developed concurrently by the Planning Office and project architect. Once the design is approved, the project is supervised by the Director of University Plant; documents for bidding and construction are prepared. Continuous cost evaluation is carried on by consultants throughout the planning and implementation processes. Interplay between program, design, and cost control throughout the process aims at insuring an effective balance of function, aesthetic quality, and economy. Campus planning consultants provide detailed coordination with the Campus Development Plan and produce a harmonious design.

3) The Planning Office coordinates the flow of information and the organization of program decisions between faculty, staff, administration, architects, and consultants. The Office of University Plant provides the technical and financial coordination through the implementation stage.

APPLICATION:

The main contributions of the study are the conceptual approach to and the comprehensiveness of the scope of planning. The exercize of "thinking through" the process followed at Rochester is a worthwhile undertaking for any college or university regardless of size or complexity of problems.

The methods are continuously used for programming new buildings and reassigning existing space. The most recent application was a comprehensive study of the Eastman School of Music. The computer programs used in the instructional load projection model have been generalized under the title MAAPS by the University of Rochester Computing Center.

REPORT: *System for Exploring Alternative Resource Commitments in Higher Education (SEARCH)*, by George F. Keane, James N. Daniel, Jr., Peat, Marwick, Mitchell and Co. (November 1968–scheduled for completion August 1970).

SUBJECT: Development and implementation of an aggregate system simulation model for use by eight colleges in a project designed to assist them to develop and update long-range plans.

INSTITUTIONS AND SPONSORS:
Concordia Teachers College, River Forest, Illinois
Franklin College, Franklin, Indiana
Loyola College, Baltimore, Maryland
Macalaster College, Saint Paul, Minnesota
Mount Aloysius Junior College, Cresson, Pennsylvania
Park College, Kansas City, Missouri
Saint Mary's College, Winora, Minnesota
Samford University, Birmingham, Alabama

Approximately one-half of the direct cost is being paid by grants from the Educational Facilities Laboratory, the ESSO Education Foundation, the Kettering Foundation and the Standard Oil of Indiana Foundation. The remainder of the direct cost and all indirect cost are being paid by the eight colleges.

SUMMARY:

OBJECTIVES:

Under the leadership of Park College, a group of eight colleges was assembled to undertake a long-range planning project with two major objectives:

1. To train key administrators and planning officers in the concepts, techniques and organization of overall institutional planning.
2. To design and implement a mathematical simulation which makes possible the exploration of a wide range of planning alternatives by enabling the planners to project resources, resource demands, and institutional characteristics quickly and easily for each alternative they wish to consider.

SCOPE:

SEARCH is a generalized simulation of a college or university as an interactive system. It encompasses students, programs, faculty, facilities and finances, functionally relating each of these aspects to the others, so that it can simulate the behavior of a college as an operating system. Beginning with the actual present state of the institution, it simulates its future state by yearly intervals for up to ten years, based upon a continuation of present operating policies and decisions, as well as alternative policies and decisions the planner wishes to explore.

For each simulated year, the model calculates all of the data items which describe the state of the institution; e.g., *state variables*, based upon the actual starting state as affected by a large number of explicit decision possibilities; e.g., *decision variables*, and environmental considerations; e.g., *environmental variables*.

SEARCH is sufficiently flexible and broad in scope to encompass the characteristics and planning information needs of institutions ranging from a two-year college with an enrollment of under 500 to a university with graduate and professional schools and enrollment in the thousands. The number of variables in a specific implementation, therefore, can vary widely, depending upon the characteristics of the institution and the level of detail it wishes to employ in planning. The initial implementation of SEARCH at Loyola College has 522 state variables, 245 decision variables, and 69 environmental variables.

22 DEVELOPMENTS IN COMPUTER-ASSISTED UNIVERSITY PLANNING

METHOD:

1. Each of the participating colleges designated a planning committee, typically consisting of the president, chief academic officer, chief business officer, development officer, and representative faculty, and in some instances, students and trustees.
2. These groups met initially for a two-day seminar conducted by a team of management consultants from Peat, Marwick, Mitchell and Co. Thereafter these committees met individually, typically for two or three hours a week. Minutes were kept and exchanged among the colleges.
3. First, attention was given to institutional goals and objectives. Then each college was asked to define its information needs for long-range planning, and the decision factors and environmental forces that would shape the future of the institution.
4. Further joint meetings were held to determine specifically those items which the simulation model should include. The consultants also visited each campus to meet with the planning committees, and to determine the availability of data needed for the simulation's data base.
5. Working from listings prepared by each college, the consultants prepared a master listing of the data, decisions, and environmental factors needed to encompass the characteristics and planning information needs of all the colleges.
6. These were then analyzed to determine the functional relationships which existed among the various components, and which would describe the behavior of the college as an operating system.
7. By mid-1969 the colleges had reached agreement on a general analytical framework which would serve as a basis for the simulation. The consultants also designed a file structure for the computer program which enabled the simulation to reflect the precise characteristics of each individual college when implemented.
8. A detailed report was prepared and the colleges then sought and obtained grants from several foundations to enable them to carry the project through to completion. The consultants were authorized to proceed with the detailed mathematical design, and the programming and testing of the simulation.

CHARACTERISTICS AND CAPABILITIES:

a. The program has been written to operate on large scale time-sharing computer systems, thus avoiding the constraints resulting from limited computer capability on campus.
b. Used in the time-sharing mode, SEARCH can also be used directly by top-level administrators without a computer specialist serving as an intermediary. Consequently the user is allowed to interact with the model between simulation runs by modifying the data base and rerunning the simulation in an interactive search for the plan which best meets the needs of the institution.
c. The program also has the capability of being run in a batch-processing mode.
d. SEARCH will enable the user to obtain a report on any state variable for any future year in the ten-year time frame.
e. Each college also has the capability of selecting logical groupings of state variables for arrangement into pre-formatted reports in areas such as enrollment, program, school, facilities, finances, etc.

APPLICATION:

Loyola College was selected for the initial implementation of SEARCH. The system was made operational in March 1970. Implementation at the ramaining colleges will occur at the rate of one or two per month thereafter, and it is anticipated that the system will be operational at all eight by the end of August 1970.

After SEARCH has been implemented and thoroughly tested at two or three colleges, it will be made generally available for implementation by other colleges.

It is expected that SEARCH can be adapted to virtually any college or university which is not heavily research oriented.

A full report of the project, including details of the computer program, was published in June 1970 by Peat, Warwick, Mitchell & Co.

Specialized Operational Programs

University of Washington
California State College, Dominquez Hills
Tulane University
Massachusetts Institute of Technology–INSITE II
University of Wisconsin
Pittsburgh Board of Public Education
Skidmore, Owings & Merrill–BOP
University of California, UCLA Library Hours
Rensselaer Polytechnic Institute–Physical Facilities
Rensselaer Polytechnic Institute–MEMOPAD

REPORT: *Computer Planning Model for Colleges and Universities*, and *Computer Graphics Simulation: The Suzzallo Quad*, by Robert W. Koski, Robert C. Meier, David L. Bonsteel, and James Donnette (1968).

SUBJECTS: I Computer program for use in the analysis of future land, building, and staff requirements.

II Graphic simulation of campus space relationships.

INSTITUTION AND SPONSORS: University of Washington, Seattle, Washington; U.S. Office of Education; Esso Education Foundation; and University of Washington.

SUMMARY:

I THE COMPUTER PLANNING MODEL

OBJECTIVE:

To provide an administratively-oriented planning tool capable of coping with the changing needs of a dynamic university or college.

SCOPE:

A systems model using computer systems possessing a maximum flexibility in output format. The model wil consist of a series of programs that provide period-by-period estimates of such requirements as future land, buildings, and staff under a set of assumptions, including the character of buildings and of the student body, educational policies, and the levels of research activity and service to the community.

The model is an information processor and is capable of producing a graphic output of charts and graphs on a Calcomp Plotter.

METHOD: These tasks must be performed:

Development of a conceptual scheme to study student/space/density relationships.
Analysis of the forms and characteristics of the necessary input data.
Conceptualization and coding of computer programs.

1. Computer Programs:
   a. Languages:
      1) COBOL-65 (Common Business Oriented Language) is a standard, high-level, business-oriented, machine-independent, procedural language. COBOL in its standard form could be used on all manufacturers' computers, making the model usable by other colleges and universities.
      2) BASIC is geared to a non-computer oriented staff. Because of this, it is used primarily for instructional purposes.
   b. Computers: Burroughs B5500 for the planning model, and IBM 7094-7040 DCS and a CalComp Plotter using GRAPHICS computer program to produce graphic displays.
   c. Inputs:
      1) User programs:
         a) FILE provides English description and inventory of terms for all coded information that will enter the model from the outside world.
         b) HIERARCHY provides decision-makers with information assembled in digestible form without losing integrity.
      2) Program for selection of data: CREATE:
         a) Selects the proper data files to be used.
         b) Accumulates totals.
         c) Provides summary of data.

      FILE, HIERARCHY, and CREATE will allow the user of the model to define, construct, and rearrange information into the most functional forms.

3) Data bank: A structured storehouse of real or simulated data. The types of deposits are:
   a) existing detailed data files,
   b) changes,
   c) previously created data summaries.

d. Output programs:

REPORT: Report writer (tabular reports).

QUESTION: Remote terminal inquiry (answers to specifications).

NARRATIVE: Exception reports in narrative form.

GRAPHICS: Graphic display on CalComp Plotter. (charts: bar, column, line, semi-log; population pyramids).

APPLICATIONS:

This particular model with its student/space/density-orientation is suitable for planning facilities. One major advantage of this model is that planners can communicate directly with the computer without needing a programmer. This man-machine interaction allows the planner to manipulate large amounts of data, to evaluate the accuracy and the usefulness of the computer output, and to alter the inputs to obtain the type of administrative results he is seeking.

II COMPUTER GRAPHICS SIMULATION: **The Suzzallo Quad.**

OBJECTIVE:

To develop a computer graphics system capable of simulating campus physical environment relationships.

SCOPE:

The spatial quality of the proposed Suzzallo Quad, a central space on the campus is simulated through the use of computer graphics output in the form of an animated 16mm film. The fine-minute film simulates the visual experience of a person "walking through" the proposed Quad and the existing spaces at each end of it.

METHOD:

1. The architects of the Quad were asked to describe their design decision processes and to list the kinds of information they needed during the process. Designs were produced from these data via computer graphics and the architects reviewed them.
2. Data formats were established for computation and digitizing of building surfaces which would determine the Quad's space. Three sets of data were then prepared to:
   a. Test program capabilities.
   b. Economize plotter use.
   c. Test formats for organizing data for ease of preparation and for usefulness in depicting architectural space.
3. Computer Program, PERSPA: A variation of a perspective program developed by the Urban Data Center at the University of Washington. Traditional architectural perspective viewpoints and data requirements were accounted for in the program.
   a. Language, FORTRAN IV.
   b. Computer, IBM 7094-7040 DCS.
   c. Plotter, EAI 3500 Tableplotter (60" x 45").

4. Output:

   a. The computer calculcated line plot; e.g., lines determined by differences between brightness and texture gradient of adjoining surfaces.

   b. Computer graphics outputs provided multiple views which were filmed with a 16mm Bolex to provide a view of the sequential path of an observer (eyed from five feet above ground) as if he were walking through the Quad.

APPLICATIONS:

The computer Graphics Simulation Program offers great possibilities as an experimental tool for campus planning. It is sufficiently developed for use on other design projects needing a simulation of spatial relationships.

NOTE: A new program, VISIM, has been developed for either CalComp plotting of individual views, or SC-4020 produced, computer-animated 16mm film. This program is written in FORTRAN IV for IBM 360-50 only at present.

REPORT: *A Communications System for Higher Education*, by J. Donald Mild* and Donald D. Doughty (1967).

SUBJECT: Data system for a new institution of higher education.

INSTITUTION AND SPONSOR: California State College, Dominguez Hills, California; Office of Education, U.S. Department of Health, Education, and Welfare.

SUMMARY:

OBJECTIVE:

To develop and implement a total information communication system for a new institution of higher education, by integrating the information resources of the organization.

SCOPE:

The data elements selected for inclusion in the system are defined in terms of information required by the operations, control, and planning activities, such as students, curriculum, faculty, staff, fiscal facilities; e.g., what kinds of plant and facilities information are essential for optimizing space utilization, planning campus construction, and maintenance? Focus was on the development of a data system which would satisfy the existing needs.

METHOD:

1. Definition of the institution's information requirements.
2. Synthesis of the operating system.
3. Development of procedures for the acquisition and processing of data.
4. Evaluation and extension of the data system to provide for decision making by management.
5. Final testing and evaluation of the system.
6. Systems Design: The five basic categories of activities are:
   a. Definition and inventory of the data base:
      1) Definition of terms.
      2) Preparation of data survey forms.
      3) Representation of data (codes).
   b. File design:
      1) Facilities file.
      2) Student file.
      3) Personnel file (faculty and staff).
      4) Fiscal file (revenues and expenditures).
   c. Data acquisition:
      1) Logical points of entry.
      2) Verification: validation, feedback.
      3) Hardware considerations.
   d. Storage and retrieval procedures (interfile linkages).
   e. Applications programming:
      1) Selection of programming languages.
      2) Use of general purpose programs and program generations.
      3) Organization of programming personnel.
7. Hardware Requirements: In the initial stages of system development, a small-scale magnetic tape computer was used. When the magnitude and level of utilization of the data base justifies it, a large-scale random access computer should be used.

*Now Director of Institutional Research at Stanislaus State College, Turlock, California.

PROBLEMS:

The original objective, to develop a system to meet existing needs, was found unrealistic: focus had to be directed to the establishment of operating concepts which would permit the development of a durable data system. Factors contributing to the change in focus were:

1. Confusion of terms and definitions of information requirements.
2. Constant state-of-change on reporting requirements.
3. Unstable operations environment caused by frequent changes of equipment, personnel and information processing objectives.
4. Lack of a general plan defining long-term objectives for the data systems.

Institutions utilizing EPD over a period of years spent up to 70 per cent of data processing personnel time changing computer programs. Attempts to establish permanent data systems which would accommodate the institution in perpetuity usually failed. The college was unable to implement more than about 10 per cent of the system designed, due to a 1968 budget reduction. This is a good illustration of the many pitfalls likely to be encountered when the design of a data system is attempted too early in the life of a new institution.

APPLICATIONS:

1. The basic system design approach has been adopted by a number of California State Colleges and by the California State College system. The open-end file and the file linkage techniques defined in the project report are now being used by several institutions.
2. The development of computer programs by California State College personnel is being done in USASI FORTRAN and USASI COBOL so that program exchange is possible where common data formats exist.
3. The California State Colleges are participating in WICHE's effort to develop a management information system, a result of which should be the adoption of a common data base terminology.
4. Newly created or existing institutions currently utilizing a sequential, traditional approach could convert to this system by extending and integrating their subsystems. Ideally, this could occur during the process of upgrading the data processing plant, providing that the change is correlated with the implementation of an overall management information system.

REPORT: *University Cost Structure and Behavior Cost Simulation Model*, by P.A. Firmin, Seymour S. Goodman, Thomas E. Hendricks, and James J. Linn (1967).

SUBJECT: Management.

INSTITUTION AND SPONSOR: Tulane University, New Orleans, Louisiana; National Science Foundation.

SUMMARY:

OBJECTIVE:

The main objective of the university cost system simulation model is to provide a useful tool for university policy makers and management for planning, controlling, and evaluating university operations. This is achieved by developing a framework for analysis and prediction of the behavior of certain cost elements and to simulate selected aspects of university cost behavior under specified conditions.

SCOPE:

1. The model does not represent a "total system." For ease in programming and application, the model has been divided into a number of modular components representing each major function of the university.
2. The model, as an analytical tool, compares interdepartmental costs. As a predictive tool, on the basis of five years of historical data (including the current year), the model simulates cost levels and behavior for the following four years.

METHOD:

1. Analyze the relationship of university goals and objectives to cost behavior. (Cost: the economic sacrifice involved in the transformation of inputs into outputs.)
2. Determine historical cost behavior for major cost elements by applying correlation and regression analysis to data obtained from several private and public universities.
3. Relate cost behavior at various levels of aggregation to variables which could influence this behavior. Enrollment was considered by far the most significant independent variable.
4. Analyze expense relationships for several specific university functions such as library, food services, housing, student activities, university-supported research, physical plant, sponsored research, and selected agency activities.
5. On the basis of empirical research, construct a model simulating the behavior of university costs, classified as teaching, administration, research, professional activities, and other.
6. TIME-SCALE PARAMETERS: Nine academic (and fiscal) years:
   a. First four years: historical data from files.
   b. Fifth year: current year of operations.
   c. Last four years: the ones immediately following the current year.
7. INPUTS:
   a. Student enrollment, by level, for the first five years of the nine-year period.
   b. Number of degrees granted in the first five-year period by level – bachelors, masters, and doctorates.
   c. Expected entering freshman enrollment and entering graduate enrollment for each of the next four years in the time span.
   d. Number of faculty members by academic rank.
   e. Academic pay scale levels for faculty salaries for the entire nine-year period (using AAUP scale).
   f. Average course load in terms of full-time equivalent credit-hour-load per semester, by levels.
   g. Academic faculty semester teaching load and section-size policy, expressed as a range between allowable minimum and allowable maximum.
8. OUTPUTS: Inputs are transformed into outputs as follows:
   a. Given total faculty requirements and rank distribution of faculty computed as the average mix of faculty over the previous five years, the absolute numbers of faculty required by rank are applied to the AAUP salary scales by rank to obtain total faculty cost for the university instructional division under consideration.

b. After total faculty cost by division has been calculated, the model calculates staff support cost at the departmental or divisional level, by using a ratio of 1:13.
c. Expenditures for supplies and expense are then calculated as a fixed proportion of faculty salaries, and the total direct instructional cost by division is obtained.
d. Cost of divisional administration is calculated as a fixed ratio (1:7) of total direct divisional costs.

Ratios for staff support and divisional administration were determined empirically from a large sample of universities.

9. MODEL OUTPUT COST CATEGORIES:

University Administration.
Basic Student Administration.
Institutional and General Expenditures.
Instructional Expenditures.
Academic Supporting
(library, computer center).
Auxiliary Enterprises
(food services, housing, bookstore).
Agency Activities
(athletics, research institutes, publications).
University Supported Research
(sabbatical leaves, faculty support).
Student Activities
(entertainment, social programs, clubs).

10. Physical Plant Expenditures are divided into four categories:
a. Administration, including expenses for maintaining the general office staff, plus engineering and architectural services and administration of the physical plant.
b. Maintenance includes payment of all kinds for all routine and special maintenance duties performed by the staff of the physical plant department.
c. Operations, including janitorial service as well as routine functions performed by other personnel. Amounts charged to utilities should include the direct cost of purchased utilities or allocated costs of self-generated utility services. In either case, these items should not be combined with operations and maintenance.
d. Sponsored research (salaries, wages, supplies, expenses, equipment).

APPLICATIONS:

1. Outputs of the cost simulation model are:
a. Prediction of enrollment for four years.
b. Distribution of faculty salaries by university function.
c. Distribution of total university expenditures by major natural expense category for each major university operating division.

Users could restructure the model relationships to produce output oriented to their own needs.

2. University administrators can address the model with questions such as:
a. "If I alter average section size (faculty-student ratios), what will be the effect on the level of university expenditures?"
b. "If I predict significant increases (decreases) in entering enrollments at either the undergraduate or graduate level, what will be the effect on faculty requirements and faculty costs if section-size policy is allowed to remain constant?"
c. "If I predict an increase in faculty strength, with a concomitant increase in salary cost of instructors, how will other expenses of university operation vary?"

Although no simulation model exists that applies universally to all institutions, the model is general enough to allow allow the individual user to incorporate in its calculations the requirements and data of his own institution.

REPORT: *Institutional Space Inventory Technique–INSITE II*, by Kreon L. Cyros, Project Director and John A. Langell, Systems Programmer (Dec. 1960).

SUBJECT: An information system for institutional space inventory and utilization studies.

INSTITUTION AND SPONSOR: Planning Office, Massachusetts Institute of Technology, Cambridge, Massachusetts.

SUMMARY:

OBJECTIVES:

1. PRIMARY: To develop a computer-based space information system for M. I. T.
2. SECONDARY: To assess existing space utilization standards in order to:
   a. Better understand the relative merits of space demands placed upon a limited availability of space resources.
   b. Derive more meaningful space indices for use in the design of future facilities.

SCOPE:

Within the framework of the Integrated Civil Engineering System (ICES) environment, to design and implement a total space information and modeling system that takes advantage of the ICES-provided dynamic storage and problem-oriented language capabilities, yet provide an efficient, flexible, and practical vehicle for achievement of the primary and secondary objectives.

METHOD:

1. THE SYSTEM: Having determined the true nature of space use and assignment at M. I. T. in order to assist institutional planners and managers in studying space inventory and its utilization, the INSITE II system evolved. The system, as structured under ICES, is composed of a language, a set of computer programs, and data files. This configuration is typical of a system which operates under ICES (sometimes called an ICES subsystem). Further, each component as found in INSITE II is typical of all ICES subsystem components of its type.
2. THE LANGUAGE: The medium through which the user communicates with the computer is the INSITE II language which falls into a special class of languages known as problem-oriented languages. More precisely, the INSITE II language is a command-structured, problem-oriented language. Commands are similar to the English language keywords with which the user would verbally describe the function which he wishes to perform or the data he wishes to input. The user thus writes a series of English language commands in the INSITE II language, possibly containing or interspersed with data, and for each command the system performs some operation. Each command can:
   a. Supply data necessary for an operation.
   b. Cause previously stored data to be retrieved.
   c. Cause data to be presented to the user in visual form.
   d. Combine any of the above actions.

   Example commands:

   1) TAKE OFF FLOOR AREA ASSIGNED TO ROOM TYPE 'OFFICE'.
   2) PRINT SPACES ASSIGNED TO ROOM TYPE 'CLASSROOM'.
3. THE COMPUTER PROGRAMS: The operations specified by the commands are accomplished by processing routines. Each command will generally cause one or more of such routines to be executed in the processing indicated by the command. The specific routines that are executed for a command will vary according to the specific form of the command, the specific data provided with the command and the specific data generated during the course of processing the command.
   a. I/O Routines: One of the most valuable features of the system's Input/Output routines is the report generator that provides a user designed, tri-level reporting capability. An example of such a report might be a tableau of net assignable square feet by Building, by Assigned User, by Room Type. The number of possible combinations of reports available is, of course, limited only by the number of data classifications stored and the imagination of the user.

b. Modeling: Another feature of the system is its capability to act as a model of the physical plant for any institution. This capability allows the user not only to derive the traditional utilization measures of square feet per occupant (by rank, if desired), for example, but to experiment with new dimensions of space indices in order to derive possibly more meaningful standards for use in the design of future facilities.

c. Bulk Reports and Specific Queries: For purely administrative purposes, the INSITE II system does provide an efficient and flexible formatted bulk reporting technique that can provide each administrator of a department or office a detailed report of the space under his administration. In addition, searches for specific spaces that fall within any number of user-designated constraints are also accomplished in an effortless manner, regardless of the size of the data base being searched.

d. Data Files: The inventory and utilization data can range in amount from very small to very large. In particular it can exceed the size of primary memory (core storage) by many times. However, because of the order of processing (and hence the order in which data are required) cannot be anticipated, any or all of the data are quickly accessible at any time. This is possible through use of the ICES environment that maintains a data file on direct access secondary storage which acts logically as an extension of primary memory. The processing programs reference all data as though it were in core at all times. The ICES environment insures that any data referenced by INSITE II is in core, possibly moving data not immediately needed to secondary storage to make room. Between computer runs all data are moved to this file so that the data can be preserved from one run to the next.

e. Data Elements: In INSITE II there are many kinds of data elements. A list of the elements presently used is as follows.

1) Organizational elements:

a) Major User of the Space—e.g., An Academic School, an Administrative Vice Presidential Organization.
b) Minor User of the Space—e.g., An Academic Department, or Administrative Office.

2) Inventory elements:

a) Space—any unique identifier will eventually be acceptable but the present version dictates a unique alphanumeric building number (1, 40, E18, NE20, 4A), a "–" separator, a floor number (99 floors maximum) and a room number (99 rooms per floor maximum).
b) Primary Room Types—e.g., Classrooms, Laboratories and Offices.
c) Secondary Room Types—e.g., Seminar Rooms, Art Studios and Administrative Offices (respective to the Primary Room Type examples above).
d) Groups—e.g., Structural Design Group, Highway Design Group and Soils Testing Group (within the Civil Engineering Department, for example).
e) Activities—e.g., Teaching, Administrative, etc.
f) Rank—the rank of the individual utilizing a particular space; e.g., Professor, Secretary, etc.

3) Aggregation elements:

a) Buildings—any uniquely identified physical facility.
b) List—any user-created list created from combinations of the above data elements.

4) Each data element has associated with it two kinds of information:

a) Data—facts which pertain uniquely to the element, e.g., the physical measurements of a space.
b) Pointers—the relationships with other elements.

Furthermore, elements may be structured hierarchically. That is to say that the Minor User elements, which might be specific academic departments, for example, can have pointers that relate with all the space elements that are assigned to those departments. Thus the problem of funding all the spaces in a department is a much easier task than found when data are stored in the traditional manner by sequential records within a data file.

APPLICATIONS:

1. INSITE II could be applied to any institution providing that adjustments are made to reflect the particular data requirements and organization of the institution. The basic hardware environment required to run INSITE II is an IBM OS/360, model 40 or better.
2. In addition to the space information applications, the system is ideally suited to aid the physical plant operations of an institution as an information source maintenance budget analyzer and a work scheduling device in such areas as building maintenance and repair.
3. A final, yet most important, application is in providing a rapid and efficient means for fulfilling the annual facilities inventory requirements for both federal and state governmental agencies.

REPORT: *A Methodology for Determining Future Physical Facilities Requirements for Institutions of Higher Education*, by John V. Yurkovich, Byron C. Bloomfield, et al. (December 1966).

SUBJECT: Computerized Methodology for Space Management and Facilities Planning.

INSTITUTION AND SPONSORS: University of Wisconsin, Madison, Wisconsin: U.S. Department of Education.

SUMMARY:

OBJECTIVES:

1. Primary: To develop a computerized methodology for determining physical facilities requirements for a large university.

2. Secondary: To assess the applicability of the methodology to institutions varying in size and nature.

SCOPE:

To develop within an eighteen-month period:

1. A space classification.
2. A computerized space inventory.
3. Computerized procedures for conducting a room utilization study and implement the study at the University of Wisconsin.
4. Computerized techniques for projecting students and staff and conduct such study for the University of Wisconsin.
5. A computerized method for projecting classroom instructional laboratory, administrative and academic office, and the respective service space requirements.

METHOD:

1. Space Classification System: The space classification system developed in this study, which was initially implemented within the University of Wisconsin system, has been replaced by the higher education facilities classification system developed by the National Center for Educational Statistics in 1968. The model described herein is currently in use and continues to meet users' needs.

   Develop space classification system as a means to group together individual spaces.

   a. Identify all types of space existing on campus and names used to designate them.
   b. Develop inventory list.
   c. Develop various grouping criteria to evolve final categories.
   d. Identify each space by the department to which it is assigned.
   e. Relate classification to reporting needs and existing information.

   Requirement: The space classification system must allow comparison of spaces by department.

2. Space Factors:

   Determine space needed by personnel and equipment, and develop space factors to be applied to the space classification system.

   a. Space factors would vary for each institution and could empirically be arrived at by determining specific space needs. (Campus planners and architects could easily derive space factors best suited to their particular institution and determine the average size of the station module in square feet.)
   b. Time considerations (frequency of usage) would have to be considered since it may alter substantially the determination of space factors; e.g., average weekly student contact hours/station.
   c. Space factors should receive the acceptance of its ultimate users and be adjustable to the demands of changing educational needs.
   d. Method to determine space factors:

      1) Empirically derive a station module (sq. ft./station).
      2) Determine station distribution (percentage within total category).
      3) Derive from (a) and (b) average area (average sq. ft./section).
      4) Assume average weekly student contact hours/station.
      5) Divide $\frac{(c)}{(d)}$ to obtain sq. ft./student.

3. Physical Facilities Inventory:

Input and Output Data Requirements: Desired output data and reports formats have to be determined according to the institution's own internal needs for space data and externally desired information. For the University of Wisconsin the following types of reports were considered necessary:

Room-by-room reports ordered by floor and building, by department, and by category, and summarizations of the areas in each category within each building, department, college, or division, and for the total campus.

a. The basic measure for space inventory is area by type:

1) gross,
2) net,
3) assignable,
4) custodial,
5) mechanical,
6) construction,
7) net non-assignable, and
8) net.

b. Input data to be collected for each room in a computerized space inventory should include:

1) Fundamental data needs (area, room identification, assignment, and space classification-designation).
2) Provisions for easily updating the room inventory file.
3) Gross area of each floor in each building must be collected.
4) Collection of only the other data which are considered essential (e.g., do not collect or inventory non-essentials such as floor slope or ceiling height).

c. Once the perpetual physical inventory is completed, more detailed information could be collected on a "one-shot" basis.

d. Inventory preparation:

1) Codes should be uniform throughout the institution.
2) Numeric codes and alphabetic abbreviations should be included in printouts for easier interpretation.
3) Set up "dummy" division and department codes for non-assigned space; e.g., General Academic Space for classrooms, General Building Space for custodial, circulation, mechanical and restroom areas. Inactive Space for areas such as "remodeling" and Miscellaneous Space for areas which were in use but not specifically assigned to a department, such as telephone booths.

4) Data collection:

a) Decisions must be made whether to use building plans or to measure each space. In the case of older buildings, the modelings could have been unrecorded. These buildings should be measured. In newer buildings a take-off could be made from construction drawings. On-site inspections are necessary to verify these data.
b) Develop diagramatic floor plans depicting data.
c) Use data sheet for each room for both collection and coding of data for keypunching.
d) Initial Inventory: Data sheet information is keypunched into cards and compiled onto a tape called the Room Inventory File. Computer audits are used to check accuracy of Room Inventory File.
e) Updating: Printouts are sent to deans and department heads to review the data on rooms assigned to them.
f) Existing Space: After up-dating and final checks a master Room Inventory File and finalized reports of existing space can be generated.
g) Future Space: Approved construction and demolitions should be incorporated into the space record to determine future space.
h) File Maintenance: Master Room Inventory Files can be maintained by using two basic procedures: Master Room Inventory Files can be maintained by using two basic procedures:

(1) Supplemental update of the files without contacting all the departments within the institution. CRM and PERT can be applied, including seven major branches: New construction, acquisitions, new leases, razing (or cancelled leases), remodeling, reassignment, and corrections.

(2) Institutional update: Once files are made current by "supplemental update," data are submitted to departments for their review and audit at least once a year. A logic network can be constructed including three networks: Room Inventory File, Departmental Instructional File, and utilization and other final reports.

4. Utilization Study:

a. Space utilization studies measure the efficiency with which existing facilities are being used.

b. Measures to determine levels of room and station utilization are:

1) average weekly room periods,
2) student station utilization rate,
3) square feet per student station,
4) square feet per student contract hour.

c. Evaluation of these levels of utilization can be derived by applying utilization standards which are unique for each individual institution. Utilization standards should be established for: sections, room period, weekly room period, student contact hour, station, FTE room, student station utilization rate, and square feet/student contact hour.

d. Updated master Room Inventory Files must contain the following information for each classroom and instructional laboratory:

1) room number,
2) building code,
3) area of room,
4. student station capacity,
5. space category.

e. An additional instructional file is necessary and should contain:

1) department in which course is taught,
2) course number,
3) section number,
4) type of instruction,
5) time of section meeting,
6) days section meeting,
7) location of section meeting,
8) number of weeks the course is taught.

f. Data of the master Room File are merged with the Instructional File on the basis of room number and building code in generating the utilization report.

g. Projections:

1) On student enrollment:

Space projections must be based on detailed student and staff (academic, administrative, and all other personnel requiring office space) projections. It was assumed that course offerings and mix of students enrolled in a department's courses will remain relatively unchanged and that other factors which influence enrollment will also remain the same. Projections of total number of students are divided by sex, marital status, class, and by school or college.

A general projection of enrollment could utilize the following techniques:

a) Ratio method to determine ratios of new freshmen by sex to the high school graduates by sex of the institution's area of patronage and utilized to project future new freshmen for the institution.
b) Projection of total freshmen by sex.
c) Cohort-survival based upon past experience of survival by sex of freshmen, sophomores, juniors, and seniors.

In large institutions size of graduate enrollment is generally a function of:

(1) The size of the freshman enrollment, and
(2) The size of grant and fellowship funds.*

*For a detailed methodology see: L. J. Lins, **Methodology of Enrollment Projections for Colleges and Universities.** Washington, D.C. American Association of Collegiate Registrars and Admissions Officers, March 1960.

2) On staff:

Student-staff ratios derived from base year relationships were used to project academic staff-FTE students by departments. Non-academic staff were also related to FTE students by division, college or institution and projected on the basis of student-staff ratios derived from base year data.

It is suggested that ratios based on the relationship of staff to student contact hours by level of enrollment be tried as an effective method for projecting academic staff.

3) On institutional space:

Space needs for a hypothetical department for a particular projection year were broken down into the following categories:

a) Instructional Laboratory,
b) Instructional Special Laboratory,
c) Instructional Laboratory Service,
d) Academic Office,
e) Academic Office Service,
f) Classroom, and
g) Classroom Service.

Student and faculty projections were made and space factors were applied to each of the above categories.

4) On research space:

Availability of funds and the increasing growth of research tend to force departments and administration to plan as the need occurs. Projection of research space is a major problem since in most cases the nature and the quality of space needs is uncertain.

APPLICATIONS:

The above methodology could be applied to any institution providing that adjustments are made to reflect the institution's peculiar needs and capabilities. It would be necessary for the institution to develop its own computer programs for data processing.

REPORT: *A Comprehensive Concept for Vocational Education Facilities*, by L.J. Kishkunas,[1] Donn Allen Carter,[2] et al. (June 1967).

SUBJECT: Computer model for facilities planning.

INSTITUTION AND SPONSOR: Pittsburgh Board of Public Education, Pittsburgh, Pa.; Bureau of Technical and Continuing Education of the Pennsylvania Department of Public Instruction.

SUMMARY:

OBJECTIVE:

To demonstrate the feasibility of a planning process that, through a series of computer models, translates a given curriculum and class schedule into facility and space requirements.

SCOPE:

While the facilities considered here are for vocational training, the concept was designed for general application to other types of educational institutions (e.g., colleges and universities).

METHOD:

1. APPROACH: Analyze basic activities of curricula and derive facility and space requirements from these basic activities. Transform facility use into actual space requirements. Layout groups of activity stations considering physical requirements (to minimize construction costs) and activity adjacency requirements (to minimize student travel time between activities).
2. COMPUTER MODELS:
   a. Simulation of courses and activities. Output: individual course facilities demands (input to second model).
   b. Revision of class schedules and analysis of related demand upon facilities. Output: set of space requirements (input to third model).
   c. Layout of courses based upon similarities in physical requirements and subject content. Output: actual physical layout printout. Final model output can be used to develop architectural drawings for new facilities and to adjust plant layout to curriculum changes. Models allow for rapid examinations of a whole set of alternative curricula, course designs, course relationships and school schedules.
3. EDUCATIONAL PLANNING PROCESS:
   a. Definition of educational goals of the school system. (Consider national goals in the context of the local situation.)
   b. Translation of educational goals into curriculum. (Monitoring and feedback mechanism to assure that the curriculum is effectively meeting the goals.)
   c. Definition of curriculum in terms of sets of activities. Development of a class schedule using classes offered, student load and teacher availability.
   d. Definition of facilities requirements based upon class schedule and activities that take place in the classes.
4. FACILITIES PLANNING PROCESS:

   Facilities requirements are translated into space requirements in a three-stage process. Each stage builds upon the results of the preceeding. A computer model is a part of each stage and provides information for decision making.

   First stage model is used to analyze class activities. Second stage model analyzes groups of related areas. Third stage model is used to develop space layouts.

   a. Stages of the Process:
      1) Detailed examination of course, student, and equipment characteristics. Classroom Model analyses class activities.

[1] Currently Superintendent of Schools, Pittsburgh, Pa.
[2] Now with Booz, Allen, Hamilton, Inc., Chicago, Ill.

2) Determination of activity station or equipment required for different sequences and combinations of activities. Cluster Model analyzes groups of related areas. At this point the types and quantities of activity stations for which the facilities should be designed to become clear.

3) Systematic description of spaces required, mechanical services for equipment, and environmental control needed.

b. Space Layout Model: Designed to interchange areas to minimize distances between course areas that should be adjacent. Trial runs of the computer model would produce the following printouts:

1) Perimeter of areas are defined by numbers indicating approximately one hundred square feet of one of the course areas.

2) Second printout replaces perimeter numbers with course names printed within the areas. Lines could be drawn by hand on printout to delineate perimeters.)

Areas of similar environmental characteristics such as high noise levels, noxious and toxic fumes, high power needs, can be outlined and preliminary adjustments made as to possible area groupings. Final space layouts can be derived by the facilities planner or architect simplifying the space arrangements provided in the printouts.

5. POTENTIAL COST OF COMPUTER ASSISTED PLANNING TECHNIQUES:

Institutional computer time rates were $6.00 per minute. Total running time for the model printouts was less than 30 minutes.

APPLICATIONS:

The rapid turn around analysis and planning time allows education planners and administrators to develop and evaluate several possible facilities layout alternatives within a limited budget and to communicate results graphically to both future space users and architects who would design the building.

REPORT: *Building Optimization Program (BOP)*, by G. Neil Harper (1968).

SUBJECT: An approach to optimizing building configuration.

INSTITUTION: Skidmore, Owings & Merrill, Chicago, Illinois.

SUMMARY:

OBJECTIVE:

To optimize a building configuration utilizing a "total building system" approach.

SCOPE:

Rather than spending elaborate methods on some isolated part of the problem, thus producing a rather coarse set of initial techniques for its solution, the total problem is treated. No direct use is made of linear programming or game theory techniques.

METHOD:

1. APPROACH:

A high-rise office building project was used to test the "total building systems" approach. BOP consists of a series of modular programs for optimizing configurations developed using the Problem Language Analysis (PLAN). The system is operational on a standard 8 K IBM 1130 with disk, card reader, and line printer.

Data were organized into four building subsystems:

a. Window Wall
b. Elevatoring
c. Heating, Ventilating, and Air conditioning
d. Structural

Each subsystem depends upon a common data base of geometry, environmental data, and design limits. A fifth subsystem including all remaining cost items in the project can be included for completeness.

2. PROGRAM PROCESS:

a. Designer specifies to the computer as little or as much as he desires about his project. BOP supplies reasonable values for missing data by default and proceeds to
b. Formulate crude internal models of the building project.
c. Test internal geometrical models against site limitations, client specifications, architectural design constraints, and code requirements.
d. For the model that possesses these tests computations are made for four dominant cost influencing elements of the building (window wall, elevatoring, mechanical, and structural subsystems).
e. Evaluate those costs along with the fifth subsystem and store the total solution on disk.

Within reasonably loose constraints additional geometrical solutions are generated, tested, and evaluated on all the admissible solutions which the procedure generates. From the output a set of indicators can be kept as to the least cost per square foot and maximum return or investment for possible future developments.

APPLICATIONS:

BOP offers facilities designers an opportunity to select an alternative where costs were generated on the basis of the total building system rather than just on a single component of the project. So-called optimum solutions may not be selected for further development; however, the designer would have sufficient information as to what premium is involved in making this decision.

REPORT: *Extension of UCLA Library Hours: An Illustrative Cost-Benefit Analysis*, by Office of Analytical Studies of the Office of the Vice President, Business & Finance, University of California, Berkeley. (1967).

SUBJECT: Cost-benefit analysis of operating education facilities.

INSTITUTION: University of California, Berkeley, California.

SUMMARY:

OBJECTIVE:

To demonstrate the applicability of cost-benefit analysis techniques to evaluate alternatives for extending library hours.

SCOPE:

The study is limited to solve the sub-optimization problem presented by the library hours and identifies the time constraint as the primary determinant of the study scope.

METHOD:

1. Analysis:
   a. Evaluate UCLA proposal for extended hours:
      1) Determine true costs.
      2) Quantify benefits resulting from expending additional funds.
   b. Propose an entirely different alternative:
      1) Add staff but maintain same schedule as proposed.
      2) For the same expenditure of funds, the extended hours of service is superior to adding staff.
   c. Based upon the systematic evaluation of costs and benefits provided by stage 1 and 2, assess if the additional expenditure is justified by the benefits involved.

2. Library Services: The three broad categories are:
   a. Reference (reference rooms, copying, and microphoto, graphic service, reserve bookrooms, reference librarians),
   b. Circulation (units of service that makes accessible material not to be used in library),
   c. Study space.

3. Quantification of Services (benefits): Problems:
   a. Multiple non-comparable objectives which are to be maximized (e.g., reference vs. circulation).
   b. No substitutability of library uses (e.g., biomedical collection vs. law library).

4. Operative Constraints:
   a. Technical: totally binding due to the physical nature of the facilities (e.g., functional interrelationships between units must operate on the same schedule).
   b. Institutional: imposed by settled policies or prior decisons (e.g., no reduction of hours will be considered).

5. Quantification of Benefits (determine indices of service):
   a. Decreasing waiting time for various services.
   b. Decrease percentage of unfilled requests.
   c. Increase number of library users without increasing waiting time or unfilled requests.
   d. List broad categories of variables under administrative control which have greatest effects on the indices of service. Sub-categories would indicate specific actions. The list of broad and sub-categories constitutes the alternatives to be analyzed, e.g., hours that the library is open, materials and facilities, procedural changes, staff changes.

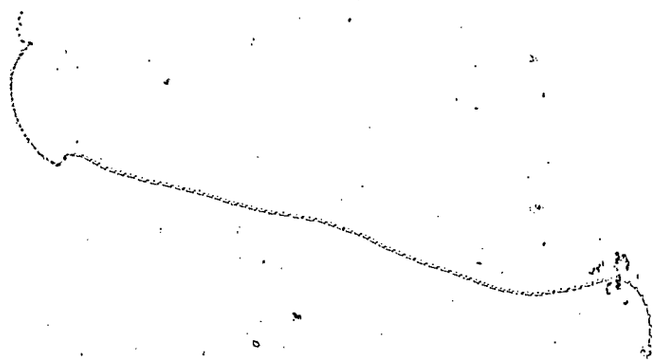
6. Evaluation of Alternatives: Compare benefits of extended hours proposals with an alternative proposal to attain the same goal (alternative to focus on increasing the staff during peak periods of demands while maintaining the same schedule of hours).

7. Choice of Alternative: Library service was previously defined in terms of circulation and reference units. Compare average cost of providing the existing level of service with average cost of new level of service (not only extended hours but in terms of overall service the library provides). A comparative table is constructed examining various alternatives and its corresponding costs (e.g., cost of program, average unit cost of service), and benefits (e.g., increases in circulation services provided over current level of operation).

APPLICATION:

Decisions are currently being made in most colleges and universities based upon limited information and intuition. The approach and method reviewed here could be applied to a wide range of other university planning problems, e.g., parking problems, expansion of physical facilities, rehabilitation of semi-obsolete structures.

As with other analytical tools, the value of cost-benefit analysis lies not only in the merit of its direct results but also in the thinking process connected with it. Administrators and university planners using cost-benefit would have to sharpen their judgment and decision-making skills. The analysis would provide them with valuable information and a sounder basis on which to formulate, evaluate, and select alternative courses of action.



REPORT: *An Exploratory Study of the Physical Facilities Requirements of Institutions of Higher Learning*, by E.B. Allen, Professor and Dean Emeritus, Graduate School, and C.H. Daniel, Vice President and Business Manager, Rensselaer Polytechnic Institute (September 1969).

Appendix: *An Approach to Projecting Area Requirements for Colleges and University Office Activities*, by D.S. Haviland, B. Forester, W.F. Winslow, Center for Architectural Research, Rensselaer Polytechnic Institute (September 1969).

SUBJECT: Simulation models for space requirements.

INSTITUTION AND SPONSOR: Rensselaer Polytechnic Institute, Troy, New York: National Science Foundation, Office of Economic and Manpower Studies.

SUMMARY:

OBJECTIVES:

1. Identification and isolation of variables affecting physical facilities requirements.
2. Formulation of models of physical facilities requirements.

SCOPE:

This study is limited to determining space requirements in terms of instructional stations. The appendix offers a method of translating these space "stations" to "square feet" of space.

METHOD:

1. Sub-models: Seven sub-models were developed, some of which can be utilized independently; others can be used as inputs to other sub-models. Sub-models are described first in words, then expressed mathematically. The model building process includes:

   inputs: the student body and its characteristics
   planning parameters: e.g., faculty loads
   simulation model: defines how inputs and parameters are to be combined
   output: the result of the operation could be either a final product or an input to other operations.

   The seven sub-models aim to determine the number of students, faculty and/or staff to be allocated to the different types of facilities, as follows:

   a. Instruction.
   b. Research.
   c. Office.
   d. Library.
   e. Housing.
   f. Dining.
   g. Parking.

   A series of assumptions are offered at the beginning of each modeling task.

2. Main Models: Main Model objective is to determine number of students, faculty and staff to be allocated to the different types of facilities, as follows:

   a. Instructional facilities by function and capacity and the number of faculty and assistants, full-time and actual.
   b. Units of research laboratories.
   c. Office facilities for faculty, graduate teaching assistants, research personnel, administration, and secretarial staff.
   d. Library with its user and active storage areas.
   e. Housing.
   f. Dining facilities.
   g. Parking facilities.

   The above are expressed in units of space so the models can be applicable to various types of educational institutions.
   This approach avoids the use of preestablished space standards (which may not be appropriate for a particular institution) and allows a particular institution to adopt space factors that best suit its educational needs and philosophy.

3. Design: The models are designed to:

   a. Determine decisions that must be made in order to determine space requirements.

b. Allow for flexibility in setting the parameters resulting from these decisions.
c. Allow comparision of results of various decisions.
d. Be useful in measuring the impact of changes in student enrollment on an academic program, or of the effect of introducing a new academic program on facilities requirements.

Each sub-model is presented sequentially; outputs of each operation represent inputs to the following. The operations are:

Input ----Decision Parameters-----The Operation---Output.

4. Sub-Model I:

a. Operation 1.1. Objective: To generate course enrollments.
b. Input: Student enrollment by degree program and academic level in a given term.
c. Decision parameters: Percentage of the number of students in each degree program, and academic level expected to take each course offered in a given term.
d. The operation: Multiply (a) student enrollment (by degree program and academic level) by (b) the percentage of the students in each of these categories expected to enroll in each course to be offered in a specific term.
e. Output: Projected course enrollment for a given term. These outputs become inputs to Operation 1.2: from diagonal matrix E.
f. Other operations of this Sub-Model I are:

1.1. Generate course enrollments.
1.2. Form diagonal matrix E.
1.3. Number of sections by course subdivisions.
1.4. Convert output of 1.3. to integers.
1.5. and
1.6. FTE instructional staff by level.
1.7. Staff by department (division & level).
1.8. Determine head count faculty.
1.9. Actual faculty by rank.
1.10. Contact hours by course and subdivision.
1.11. and
1.12. Calculate average number of students per section.
1.13. Rearrangement of 1.12. to perform 1.14.
1.14. Room capacity by student numbers.
1.15. Tally of weekly contact hours by capacity ranges.
1.16. Number of rooms by capacity and subdivision type.
1.17. Integral number of rooms by capacity and subdivision type.

MATHEMATICAL MODELS

I. Sub-Model II, RESEARCH FACILITIES: The problems to be solved by this sub-model are:

a. Given the actual number of profession faculty by department, find the number of faculty members to be provided with faculty-experimental research laboratories.
b. Given the student enrollment by degree program and academic level, find the number of students to be provided with experimental research laboratories by degree program.
c. Operations are:

2.1. Faculty experimental research laboratories.
2.2. Student enrollment by degree program.
2.3. and
2.4. Number of students by degree program engaged in experimental research.
2.5. Number of students by degree program, engaged in each experimental research project.
2.6. Number of experimental laboratories required for students engaged in each research project by degree program.
2.7. Laboratory capacity, in stations, for each different research project in a degree program.
2.8. Ibid., for research staff.
2.9. Large installations for experimental research.

2. Sub-Model III, OFFICE FACILITIES: For instruction staff, students engaged in theoretical research, secretarial and administrative personnel for instructional and research staff.

Operations are:

3.1. Instructional and research staff offices.
3.2. Offices for students engaged in theoretical research.
3.3. Administrative office facilities
3.4. Tabulation of personnel for Operation 3.5.
3.5. Offices required.

3. Sub-Model IV, LIBRARY FACILITIES: The current practice is to plan libraries on the basis of an independent estimate of the acquisition rate. The needed approach is to base planning on what is needed to satisfy the requirements of the planned research and instructional programs of the institution.

a. The problem is to determine the minimum number of books and journal titles required to establish and support the degree programs of the institution.
b. Functional stages:
   1) User facilities, e.g., general reading areas, carrels, microviewing, study.
   2) Active storage facilities, e.g., stacks for books and bound periodicals, current book and journal display, map and print storage, microfilm storage, programmed learning, music tapes, microcard storage, slides, music record and newspaper storage.
   3) Staff work facilities, e.g., acquisitions, bibliography, cataloging, circulation, historical collections, information retrieval and data processing, microprocessing, orders and interlibrary loans, photo reproduction, periodicals, receiving and shipping, reference, repair and binding.

Library facilities have been considered as a single unit regardless of the physical locations of the (possibly diverse) facilities.

Operations are:

c. User facilities:

4.1. Total number of professional faculty.
4.2. Professional faculty library users (number of faculty to use the library simultaneously).
4.3. Total research staff by department (or division).
4.4. Total institution research staff.
4.5. Research staff library users.
4.6. Total administrative personnel in certain groups.
4.7. Administrative library users.
4.8. Total student enrollment (same as 1.1.).
4.9. Student library users.

d. Active storage facilities:

4.10. Vector formation for operation 4.11.
4.11. Total books required by degree program.
4.12. Total books required for *all* degree programs.
4.13. Total professional faculty and research staff by department (or division).
4.14. Books required for professional faculty and research staff by department.
4.15. Total number of books required by all professional faculty and research staff.
4.16. Total administrative staff, omitting secretaries.
4.17. Books required for administrative personnel.
4.18. Total books required.
4.19. through
4.25. Total journal titles required.

e. Storage units for library holdings:

4.26. Number of books to be shelved, to be put on microfilm and microcards.
4.27. Total journal volumes deposited in library.
4.28. Number of journal volumes to be shelved, put on microfilm.
4.29. Total newspaper volumes to be deposited in library.
4.30. Number of newspaper volumes to be shelved and put on microfilm.

4.31. Number of programmed learning and/or self-instruction tapes and music tapes to be deposited in the library.
4.32. Formation of row vectors for operation 4.33.
4.33. Required microfilm reels.
4.34. Total number of tapes and microfilm reels to be stored.
4.35. through
4.39. Various storage units required.

Outputs are in terms of storage units. Staff work requirements are determined in each case by the university.

4. Sub-Model V, STUDENTS HOUSING:

5.1. Number of students by category (5 total), e.g., (1) single male undergraduates, (2) single female undergraduates, (3) single male graduates, (4) ibid. females, and (5) married students).
5.2. Number of non-commuting students by category.
5.3. Number of students to be housed.

5. Sub-Model VI, DINING FACILITIES:

6.1. Dining facilities - number of students to be housed.
6.2. Total number of non-resident students.
6.3. Total number of administrative personnel (8 groups).
6.4 Total number of instruction and research connected secretaries.
6.5. Formation of row vector for operation 6.6. (arrange inputs for 6.6.).
6.6. Maximum number to be provided with dining facilities.

6. Sub-Model VII, PARKING FACILITIES:

Two types of parking (a) on or near campus
(b) near living and dining facilities
7.2. Number of non-commuting students allowed to have an automobile.
7.2. Arrange inputs to 7.3.
7.3. Total number of student parking units on or near campus.
7.4. Formation of matrices for 7.5.
7.5. Total number of professional faculty and research staff parking units on or near campus.
7.6 Inputs to 7.7.
7.7. Total number of administration personnel parking units on or near campus.
7.8. Inputs to 7.8.
7.9. Total number of instruction and research connected secretaries, staff workers, and service employees, parking units on or near campus.
7.10. Total number of automobile parking units on or near campus.
7.11. Total number of parking units on or near campus for scooters, motorcycles, bicycles.
7.12. Number of bus parking units on or near campus.
7.13. through 7.20, Parking facilities near living and dining facilities.

CONCLUSIONS:

1. Variables affecting requirements for certain types of facilities can be isolated and linked mathematically to form models of facilities needs.
2. Areas such as research space and administration space are extremely difficult to model in any meaningful way.
3. The sub-models can be built using relatively little input data.
4. Controllable factors: the type and amount of information regarding how things are done, required by decision parameters, are the *key* factors. Lack of information to form the bases for quantifying these parameters suggests that this could be the major problem to be faced when attempting to develop a planning capability at a college or university.

APPENDIX:

An Approach to Projecting Area Requirements for College and University Office Activities, a case study and detailed step-by-step description of the approach and a discussion of space allocation by short- and long-range budgeting.

181. Facilities requirements:

a. Objective of model: To translate personnel and curricula into square-foot requirements.
b. The series of sub-models places students, programs, instructional approaches, and departmental profiles

into the stations required for various activities, such as the number and type of instructional stations, housing stations, etc.

c. Then these "units of space demand" are translated into real space.

2. Characteristics of the sub-model:

a. The sub-model is used in two "modes":

1) Long-range budgeting mode.
2) Short-range planning mode.

b. Problems of developing and applying universal space factors or standards:

1) Existing planning standards often do not take new educational philosophies into account.
2) Lack of measurement methodology (past approaches were of a survey-and-consensus type, trial and error, rather than a real analysis of human activity in space and human reactions to space).

3. A case study—Offices:

a. Full translation of the sub-model into square footage planning factors is not feasible.

b. The offices were selected because they are relatively "uncomplex" facilities; most traditional space planning methods do not adequately reflect the patterns of human activity within them: they simply perpetuate the existing rank-sized office scheme.

c. Range of activities:

1) Users keep diaries in which daily office activities are recorded; e.g.,

Activity	Location
Park car near office.	Parking lot
Inform secretary of presence.	Corridor
Grade papers.	Office seating area
Eat lunch.	Desk
Read.	Desk

2) Activities are grouped by their space implications; e.g., zones of related activities, such as desk and all desk-oriented activities, are established, and sized appropriately.

Zone	Size Range (in square feet)
A Desk	25 - 90
B Adjunct work table	40 - 60
C Shelf storage	32 - 48
D File storage	40 - 80
G Small group conference (7 x 5)	35 - 48
H Medium group conference (12 x 16)	140 - 200
I Large group conference (16 x 28)	240 - 450
J Special work (copying, drafting, computer terminal	20 - 60
K Special storage	15 - 70
L Special group (staff lounges, special reception, and waiting areas)	60 - 130

c. Other considerations:

1) Combining the activity zones into space.
2) Space efficiency.
3) Compatibility.
4) Dedication (single user versus shareholders, accessibility).
5) Privacy.

APPLICATIONS:

Universities with a limited capability in operations research and systems analysis would find this study helpful in determining space requirements and estimating costs.

19

REPORT: *MEMOPAD - A Computerized Program for the Maintenance of University Facilities*, by Dennis P. Jones (1968).

SUBJECT: Management.

INSTITUTION: Renssalaer Polytechnic Institute, Troy, New York.

SUMMARY:

OBJECTIVE:

MEMOPAD is a computerized system designed to aid Buildings and Grounds in the management of the physical plant maintenance.

SCOPE:

MEMOPAD was designed for RPI but is adaptable to other campuses. It is not an "automated scheduling" but rather a management tool for the systematic recording, organizing, and timely playback of maintenance information and decisions.

METHOD:

Based upon the cyclic nature of a planned maintenance program,* it produces a sequence of timely "alerts" to coming maintenance requirements and their related events. Without programming modifications, MEMOPAD can be adapted to a variety of cyclic problems of which "planned maintenance" is a classic example.

1. A master file on the Buildings and Grounds activities was developed. Each record was controlled by a four-coded field:
   a. Responsible shop, e.g., paint.
   b. Location of the work, e.g., Pittsburgh Building.
   c. Additional location, e.g., sub-basement.
   d. Activity, e.g., paint ceilings and walls.
2. MEMOPAD developed such time parameters as:
   a. Last date (in year and weeks) this activity was completed.
   b. Cycling time (in years and weeks) to next completing date.
   c. Necessary lead times (in number of weeks) required to meet the calculated due-date.
3. Provisions were made for emergency situations that have not cycled out. A punch card is prepared and entered into the computer to activate the proper record.
4. When a record has cycled out and becomes active again, the computer issues transaction notices to Buildings and Grounds. The system will continue to monitor these transactions until they are returned.
5. A status report will be issued during each monitor run to let Buildings and Grounds management know the following:
   a. What actions were due.
   b. What actions were taken.
   c. What actions are late.
6. At the same time that the status report is issued, new transactions are made available and a list of these new transactions is also prepared.

APPLICATIONS:

These reports are intended to assist Buildings and Grounds in keeping up with the growing amount of maintenance requirements due to the institute's steady expansion. The program is capable of future expansion into other areas such as automatic purchasing procedures and inventory requirements.

*See Daniel, Clarence H. **Planned Preventive Maintenance Program.** Paper presented at the Workshop for Buildings and Grounds Administrators sponsored by the New York Education Department, July 6-9, 1965.

Comprehensive Developmental Program

Peat, Marwick, Mitchell & Co. — RAPID

REPORT: *Remote Access Planning for Institutional Development (RAPID)*, by James N. Daniel, Jr., Daniel D. Robinson, and Collin W. Scarborough (June 1967).

SUBJECT: Computer-assisted long-range planning for colleges and universities.

INSTITUTION AND SPONSOR: Peat, Marwick, Mitchell & Co., Boston, Mass. A seminar in which the RAPID simulation was used as a teaching device was sponsored by PMM&Co. for its client colleges in June of 1967. During 1968 and 1969 similar seminars were subsequently sponsored by the American Council on Education, Providence College, Park College, Wisconsin State University, the State Street Bank and Trust Company for a group of New England Colleges, the Great Lakes Colleges Association, the Eastern Association of College and University Business Officers, the Association for Institutional Research, and Fairfield University.

SUMMARY:

OBJECTIVES:

1. To present the basic concepts and techniques of goal setting and long-range planning.
2. To introduce the concept of computer planning models as tools for effective long-range planning.
3. To illustrate that long-range plans should be dynamic and are affected by changing goals and environments.

SCOPE:

RAPID was designed to illustrate how a planning model could assist colleges and universities in the development and updating of long-range plans. RAPID projects resource demands and many other characteristics, such as degrees and credit hours produced, AAUP salary ratings, space utilization, etc., for ten consecutive years. For each simulated year, the model calculates 165 characteristics (state variables), which are based on 43 explicit decisions and 21 environmental parameters. A report can be obtained on any of the state variables for any future year. Pre-formatted reports are generated covering finances, facilities, and the characteristics of each college of the university.

METHOD:

RAPID was used in a seminar designed for top-level administrators and trustees of colleges and universities.

1. After introductory lectures on planning concepts and methodology, participants were given case material which contained a detailed description of a hypothetical, but realistic, university. Included was a ten-year plan with a number of undesirable characteristics.
2. The participants were then subdivided into teams of four or five, and each member was assigned a role as a college administrator or trustee which differed from his real-life role. Each team was asked to develop an improved ten-year plan for Fairfax University.
3. The RAPID simulation model, containing the characteristics and the ten-year plan of the University, was stored on time-sharing computers in Boston and Washington, and the participants had access to the computer on a remote terminal via telephone lines. Alternative decision possibilities could be entered and the impact on the institution immediately calculated and reported back. Teams would typically test out many alternative plans before selecting their ten-year plan.
4. Team plans were then compared and analyzed, after which a second case problem was presented. The teams had to revise their ten-year plan in response to new conditions which were postulated.

APPLICATIONS:

The RAPID model was developed specifically for seminar use. It is available as a teaching device to universities which offer graduate programs in college and university administration, or graduate business schools that wish to use the program to illustrate the application of management science techniques.

Specialized Developmental Programs

Stanford University–INFO

Princeton University

Caudill Rowlett Scott

Northeastern University–CORELAP

University of Miami

REPORT: *Project INFO (Information Network for Operations)*, by Information Systems Office, Stanford University (1969).

SUBJECT: Pilot study on a data-management system for a university.

INSTITUTION AND SPONSOR: Stanford University, Stanford, California; Ford Foundation.

SUMMARY:

OBJECTIVE:

To design, test, and evaluate an integrated information system for collecting, processing and utilizing data for the administrative and management functions of the university.

SCOPE:

To develop a coordinated administrative information system - based on file sharing - to improve the efficiency of Stanford University without compromising individualism or quality of education.

METHOD:

1. Evaluate available computer software programs for data-management systems.
2. Select several software packages for detailed analysis.
3. Create sample data bases using INFO data elements.
4. Install remote terminals (typewritten and visual display devices) to be used with on-campus and off-campus computers.
5. Testing and evaluation of existing systems did not satisfy cost and other INFO requirements.
6. Draft specifications for a software package capable of providing data-management and terminal-service functions within Stanford's adminstrative environment.
7. Integration of records from different areas within the university (students, alumni, personnel, accounting, purchasing, and other) into a central data base inorder to reduce or eliminate redundancy.
8. Develop new data for institutional self-study and management purposes.
9. Outline basic requirements for a data-management system.
10. Create and maintain files, query, and retrieve data from these files; use files to generate reports.
11. Develop a new data-management system specification for the services desired for Stanford's environment.
12. Criteria include:
    a. Provision for rapid online access to university data based from remote terminals.
    b. Utilization of medium-scale computing hardware with relatively small memory size.
    c. Compact, efficient and economical data storage.
    d. Simple and direct maintenance.
    e. Security techniques extended to the field level.
    f. System should adapt to unsophisticated user's needs.
    g. System should provide two levels of report service:
        1) Standard periodic batch-report.
        2) A method to describe and obtain one-time reports quickly and with some degree of flexibility.

APPLICATION:

1. Day-to-day administrative operational activities.
2. Authorized users can query the file from remote terminals.
3. Use of data base for top management planning purposes such as budgeting, long-term projections, and resource allocation.

REPORT: *Resource Allocation Study*, by P. Benacerraf, W.G. Bowen, and W.W. Lewis (July 1968 - in progress).

SUBJECT: Application of planning, programming and budgeting concepts to university planning.

INSTITUTION AND SPONSOR: Princeton University, Princeton, New Jersey; Ford Foundation.

SUMMARY:

OBJECTIVE:

To systematically examine the allocation and use of resources in universities, with special attention given to the budgetary process.

SCOPE:

The study focuses on three of the principal tools for university resource allocation and decision-making:

1. Budget-making.
2. Scheduling of space and time.
3. Evaluation of teaching and teaching methods.

METHOD:

To design a general information system both for record-keeping and for the evaluation of possible consequences of alternative policy decisions.

1. To develop a budget in program terms to frame such alternatives.
2. To develop a system for establishing and updating a long-range (five-year) planning framework within which annual budgetary decisions are to take place.

REPORT: *Determination of Space Requirements for Colleges and Universities* by Caudill Rowlett Scott, Inc. (1968).

SUBJECT: Physical facilities planning.

INSTITUTION: Caudill Rowlett Scott, Inc., Houston, Texas

SUMMARY:

OBJECTIVES:

1. To design a systematic procedure for the analysis and projection of space.
2. To develop data inputs necessary to project a building program. With computer assistance projections can be updated easily and quickly as new information becomes available.

METHOD:

1. Determination of Future Enrollment: Alternative methods:
   a. Policy determination.
   b. Historical trend analysis.
   c. Assessment of state and institutional potentials.
2. Projection of FTE Enrollment by Majors:
   a. Breakdown of estimated future total enrollment by departments or disciplines.
   b. Distribution to be made by majors; other categories programed to determine contact hours.
3. Cross-Over Study to Obtain Projected Course Enrollment:
   a. Analysis of credit hours in department by major would show how many students "cross-over" to other disciplines in their course work. Projected course enrollment figures will provide the basis for estimating space, faculty, staff, budget requirements, and to determine affinities between departments (e.g., student traffic, common interests).
   b. Computer printouts would show totals by level and major, and percentage of major and of total credits, of subjects taught for selected departments by other departments, as well as projections for FTE majors of total credits to be taught by discipline and by level.
4. Derivation of Total Contact Hours:

Course Enrollments	X	Credit Hours Per Course Enrollment	=	Total Projected Credit Hours	X	Contact Hour Per Credit Hours	=	Total Contact Hours

5. Distribution of Contact Hours to Lecture and Lab:

Projected Contact Hours	X	Per Cent Lecture Hours	=	Projected Lecture Hours	or	Per Cent Lab Hours	=	Projected Lab Hours

Computer printout would show projected distribution of clock hours to lecture and lab for FTE majors by discipline.

6. Lecture Contact Hours Distribution by Class Size:
   a. Institutional policies would determine teaching methods and class or group size for instruction in seminar, discussion, and lecture. Class size would determine amount of space needed for a student station in a lecture room.
   b. Computer printouts would provide the distribution of lecture clock hours by class sizes (projected to a specified target date) based upon estimated majors.

7. Utilization of Existing Space:
   a. Analysis of current utilization would display current student station utilization, room utilization, and area per student station by space type.
   b. Computer printouts would show existing space utilization by room type and capacity, and percentage of room utilization.

8. Lecture Planning Criteria and Space Projections:
   a. Criteria:
      1) Determine unit area per contact hour by determining the number of periods per week of room use, percentage of student use, and desired area per student station for each class size range (e.g., 1-20, 21-35, 36-50, 50+).
      2) This unit area, multiplied by the contact hours, will determine required space.

   (Standards for appropriate area student station requirements can be derived by comparing existing conditions with U.S. Office of Education survey figures).

   b. Space Projections:
      1) Area per Contact Hour x Contact Hours = Net Lecture Area (per each class size).
      2) Repeat operation for each class size; and estimated percentage of support area is added to each.
      3) Computer printouts would show estimates of total lecture space for FTE majors by discipline.

9. Laboratory Planning Criteria and Space Projections (same process as 8 above):
   a. Criteria will vary among disciplines, due to differences in equipment and intensity of use.

Lab Contact	x	Area Per Contact	=	Lab Area	+	Per Cent Support	=	Required Lab Area

10. Projections of Number of Faculty and Faculty Office Area:
   a. Faculty Number:
      1) Policy decision would determine faculty teaching load.
      2) Number of FTE faculty can be determined by dividing total projected credit hours (previously determined) to be taught and the hours to be taught by each faculty member:

         Total Credit Hours ÷ Credit Hours per FTE Faculty = FTE Faculty.

   b. Faculty Office Area:
      1) Adopt office area standards for faculty offices secretaries (ratios of secretarial/clerical staff to faculty), chairmen, and support (e.g., closet, duplication, and storage facilities).
      2) Apply standards to previously estimated faculty to derive total office area (and breakdowns).

11. Research Area Projections:

   The extent of future research activities must be determined or assumed (e.g., contract research). Project faculty and graduate students conducting research can be used as a guide to estimating space requirements:

Graduate	Faculty
FTE x Unit Area = Required Area;	FTE x Unit Area = Required Area.

12. Special Department Facilities (rooms, spaces, or buildings other than offices, general classrooms, and teaching laboratories (e.g., conference rooms, lounges, museums, libraries):

   Policy decisions must be made to determine which special facilities not currently available would be needed for future instruction, research, and other departmental activity.

13. Projected Area Summary:

   Lecture, lab, office, research, and special facilities must be totalled to obtain net area requirements for each discipline or department.

14. Support Facilities (this stage completes the projection of all spaces necessary to support the activities of the estimated student enrollment:) Policy guidelines and appropriate space standards must be developed to determine non-instructional facilities functions:
    a. Library (book storage, reader stations, faculty stations, service).
    b. Administration.
    c. Educational media center (instructional television, audiovisual aids, computer center, duplicating center).
    d. Student staff services (college center, health, staff services, chapel).
    e. Student housing and food service.
    f. Continuing education center.
    g. Parking.
15. Space Analysis: Determine which spaces are to be demolished and which are to remain. Relate this space to the above space requirements and determine possible shortages. Policy decisions would have to be made as to possible reallocations of space and location and stage development of each discipline.
16. Affinities among Disciplines and Support Facilities: The determination of affinities among disciplines will provide insights as to possible locations and groupings of instructional and support facilities.
    a. Objective criteria for judging relative affinity are:
        1) Student cross-registration translated into trips between facilities.
        2) Joining research requirements.
        3) Access needs to library, housing, service, or parking.
        4) Interdisciplinary curriculum.
    b. Subjective criteria include such affinities as the desire by the fine arts people to be grouped even though there may not be a functional need.
17. Projected Building Program:
    a. Translate net space needs into gross building requirements. Add to the assignable space halls, toilets, circulation, and other non-assignable space.
    b. The efficiency will be the net-to-gross ratio. Gross area will determine ground area coverage, floor area ratio density requirements, staging, budgeting, and other development criteria.

APPLICATION:

University administrators could use this method to gain a first approximation of future capital investment needs.

REPORT: *Computerized Relationship Layout Planning (CORELAP)** by Robert C. Lee (1966).

SUBJECT: School space layout model.

INSTITUTION: Northeastern University, Boston, Massachusetts.

SUMMARY:

OBJECTIVES:

1. MODEL: To produce recommended spatial arrangements using a basic design criteria.
2. PROGRAM: To determine a spatial arrangement for a one-floor building.

SCOPE:

The model provides information for space planning for school buildings, utilizing high-speed computers to determine the efficiency of alternative spatial arrangements. The computer program is currently limited to forty individual course areas, but capable of increase in scope.

METHOD:

CORELAP operates without the input of a building plan and generates a proposed building outline.

1. Program input:
   a. Number of individual course areas to be considered (40 maximum).
   b. Tentative spatial arrangement of individual course areas.
   c. List of any course area (or other activity center) which is to remain fixed in the location specified in b. above.
   d. List of values (based upon an adjacency index) indicating quantitatively the desirability of locating two course areas adjacent to each other for each possible pair of course areas.
2. Operation of Program:
   a. Determine the sum of all the products of the adjacency index times the distance between the centers of each pair of course areas for the initial space arrangement. Reduce this sum to a minimum so that pairs of course areas having the highest adjacency indices will be located nearest each other (within the confines of the building and/or any other restrictions imposed).
   b. Switch location of course areas (fixed locations excepted) if they:
      1) Are the same size,
      2) Have a common border, or
      3) Both border on a single third course area.

      From a given arrangement it determines all such possible changes.
   c. Choose the one which creates the greatest decrease in the adjacency index times distance total.
   d. Repeat this procedure with the improved arrangement until the optimum arrangement is reached.
   e. Print out the final most efficient arrangement together with the final adjacency index times distance total.

APPLICATIONS:

The model is applicable as a design factor and space planning tool for completely new buildings. It cannot be used where the space planning must be done within the limitations of a specific building.

LIMITATIONS:

The spatial array of the printout is limited to a 30X30 unit rectangular array, so that the building configuration must be fitted within this array; e.g., for a 300 X 300-foot (or a 100 X 300-foot) building, each unit in the array would be 10 feet; for a 300 X 600-foot building, each unit of the array would be 20 square feet.

*Unpublished M.S. thesis, Northeastern University, Boston, Mass., 1966.

REPORT: *University of Miami Model*, by Matt W. Steele (1968).

SUBJECT: Cost simulation model.

INSTITUTION: University of Miami, Coral Gables, Florida.

SUMMARY:

OBJECTIVE:

To describe interrelationships between all relevant variables in determining overall income and expenditures for one academic year.

METHOD:

1. The model is divided into six parts:
   a. Academic.
   b. Administration.
   c. Non-academic income producing areas.
   d. University capital expenditures.
   e. Research.
   f. Maintenance.

   Every element is further divided into several components covering enrollment, faculty and staff needs, supplies, equipment and space. Currently only Part IA of the academic model for the eight major schools at the University of Miami has been developed.

2. Basic elements of the model:
   a. Variables (structure of system).
   b. Relations among variables (functions of system).
   c. Independent variables:
      1) Policy variables (to be established and changed by the administration).
      2) Fixed variable (e.g., minimum square feet per student station which is regulated by local laws).
   d. Major policy variables:
      1) Total enrollment.
      2) Proportion of enrollment in each school and in under-graduate and graduate levels of each school (student mix).
      3) Mean class size.
      4) Mean teaching load.
      5) Mean tuition.
      6) Mean faculty salary.
      7) Number of faculty.

3. The model simulates the effect upon all variables of a change in one or more variables. Tracing the effect of the change of one or more variables upon all others is conceptualized as a "path" through the model. Of an almost infinite number of paths, five were selected for the academic model. Each path has a different starting point within the system and requires a slightly different computer program.

4. One path starts with the student enrollment variable.
   a. A computer program is written for the academic model with any desired actual enrollment being simulated in order to determine its effect on all other variables.
   b. In any one simulation, all variables are either classified as independent or dependent.
   c. Actual values (parameters) are assigned to the independent variables. The values for the dependent variables are then calculated (derived) by the model.
   d. Five possible paths for the academic model (starting points are "given" basic policy variables).

      Path I: Starting point: Enrollment.
      Basic dependent variables: Faculty and instructional space needed.

Path II: Starting point: Number of faculty.
Basic dependent variable: Enrollment size given various mean teaching loads.
given various mean teaching loads.
Path III: Starting point: Number of course enrollments.
Basic dependent variables: Faculty needed at various mean teaching loads.
Path IV: Starting point: Amount of instructional space.
Basic dependent variable: Resulting size of enrollment.
Path V: Starting point: Two simultaneous ones: 1, fixed enrollment; 2, fixed faculty.
Basic dependent variable: Mean teaching load.

Currently Path I is operational at the departmental level.

APPLICATIONS:

1. The model methodology is clear-cut and sufficiently universal to be adapted by universities of various sizes and degrees of sophistication as a policy decision tool. The model was run on a IBM 7040 using FORTRAN language which makes it easily adaptable to other users.
2. The possible paths allow for various avenues of inquiry into the possible impact of policy decision into the behavior of the university system; for instance, Path I represents a clear-cut approach to determining space needs for instruction, the derived costs of ancillary facilities, supplies, equipment, and a range of other dependent variables (student aid, faculty and staff expense, other budgets), as well as academic unit, university-wide, and total unit costs. The model represents a valuable contribution to university planning for administration and institutional research.

III

COMPARATIVE MATRIX OF PLANNING ELEMENTS

A conceptual framework for the comparative analysis of planning models was developed into Table 1 and titled "Comparative Matrix of Planning Elements."

The basic characteristics of the models and their component planning elements provided the basis for classification.

The comparative matrix presents a classification system in skeletal form. Other classification systems are possible, especially for the subheadings under "projections." The relevance of the comparative matrix is its illustration of the frequency of occurence of the various planning elements using a conceptual framework rather than presenting a detailed model classification.

From over 40 models surveyed, 21 were found to be sufficiently distinctive to warrant reporting. Some of the more comprehensive models are rather complex systems containing particular submodels of different types. The planning elements presented in each model were identified and classified under four main headings:

1. Management
2. Projections
3. Resource Allocation
4. Physical Facilities

An additional classification, Scope and Status, was included to indicate the degree of operativeness for each of the models reported.

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Table 1. Comparative Matrix of Planning Elements

Planning Elements / Institutional Research	Management			Projections		Resource Allocation			Physical Facilities					Scope and Status of Study					
	Management Information System	Data Management System	Program Evaluation and Review	Enrollment Calculations	Budgeting Calculations	Land Use Requirements	Cost-Benefit Analysis	Cost Simulation Models	Space Requirements	Costs of Facilities	Maintenance Programs	Computer Graphics Simulation	Space Allocation Model	Comprehensive	Specialized	Developmental	In Progress	Completed	Operational
1 University of California				x				x	x			x		x				x	
2 Michigan State University				x				x				x		x				x	x
3 University of Toronto Campus	x	x	x	x		x		x	x					x				x	x
4 Peat, Marwick, Mitchell & Co. SEARCH	x	x		x		x		x						x				x	x
5 University of Rochester	x			x					x			x		x				x	x
6 University of Washington				x	x							x	x		x			x	x
7 Dominguez Hills State College		x		x											x			x	x
8 Tulane University				x		x		x							x			x	x
9 Massachusetts Institute of Technology		x							x			x	x		x			x	x
10 University of Wisconsin				x					x						x			x	x
11 Pittsburgh Board of Education									x	x		x			x			x	x
12 Skidmore, Owings & Merrill BOF									x	x					x			x	x
13 UCLA-Library Hours							x		x	x					x			x	x
14 Rensselaer Polytechnic Institute				x					x	x		x			x			x	x
15 R P I - MEMOPAD		x									x				x			x	x
16 P M M - RAPID				x		x		x						x		x		x	x
17 Stanford University - INFO		x		x		x									x	x	x		
18 Princeton University			x			x		x							x	x	x		
19 Caudill Rowlett Scott				x					x			x			x			x	x
20 C O R E L A P									x			x			x	x		x	x
21 University of Miami				x		x		x	x							x		x	
Frequency of Occurence	3	6	2	14	1	7	1	8	12	4	1	9	2	6	14	5	2	19	17

Table 2. Planning Elements in the Twenty-One Case Studies Reviewed: Frequency of Occurrence, Percentage of Total, and Ranking.*

Planning Elements	Frequency of Occurrence	Percentage of Total	Ranking
Enrollment Calculations	14	67	1
Space Requirements	12	57	2
Space Allocation Models	9	43	3
Cost Simulation Models	8	38	4
Budget Calculations	7	33	5
Data Management System	6	29	6
Cost of Facilities	4	19	7
Management Information System	3	14	8
Computer Graphics Simulation	2	0.95	9
Program Evaluation and Review	2	0.95	10
Land Use Requirements	1	0.47	10
Maintenance Program	1	0.47	10
Cost Benefit Analysis	1	0.47	10

* All case studies utilized computer models or EDP programs of varying degrees of complexity

Table 3. Scope of the Twenty-One Case Studies Reviewed Frequency of Occurrence and Percentage of Total

Scope of Study	Frequency of Occurrence	Percentage of Total
Specialized	14	67
Comprehensive	6	29
Developmental	5	24

Table 4. Status of the Twenty-One Case Studies Reviewed: Frequency of Occurrence and Percentage of Total.

Status of Study	Frequency of Occurrence	Percentage of Total
Completed	19	90
Operational	17	80
In Progress	2	.95

IV
CONCLUSIONS

Planning techniques as currently utilized in colleges and universities have only begun to fulfill their potential as management tools.

The critical survey of the selected samples presented in this study clearly indicates severe lags in the current scope and comprehensiveness of university planning. In the light of these lags, one might question the real significance of the planning techniques currently utilized in institutional planning. Other valid questions related to their implementation could also be raised since some of the techniques discussed were developed more in the realm of academic research than as operational tools for university planning. A partial answer to the latter is found in Table 4 which indicates that 80 percent of the techniques discussed are operational and being implemented.

The main problem identified in this study has not been the lack of real significance of the techniques analyzed, but rather their limited scope within the university's total planning needs. The fact that only 29 percent of the samples exhibited some degree of comprehensiveness in their planning approach further reinforces this finding.

One of the reasons these techniques represent only partial solutions is that they were developed to respond to specific problems, isolated from the total institutional system, which includes administration, financial, academic, and facilities planning.

This non-systems approach indicates a lack of understanding and interest on the part of most university administrators to view institutional development within a total systems plan. The methodology for university planning which prefaced the review on current techniques showed how all the different subsystems and tools fit into an operational whole. This conceptual approach showed when and where the various techniques were utilized and what necessary complementary elements should be considered in the overall planning process.

The methodology presented in section I C (p. 4) is purposely normative and offers a general conceptual framework clarifying the main tasks, sub-tasks, feed-backs, and tools necessary to undertake a comprehensive university planning effort. The reader can adjust this conceptual scheme to the specific needs and peculiarities of his institution to make this general methodology operational.

Viewed within this context, the question of why more of the techniques reported in this study are not being implemented becomes clearer. The fact that few universities are employing a rigorous planning methodology to analyze their needs and resources and to charter their development as discussed above is one of the reasons. Another is that institutional administrators, in general, are not as sophisticated as the investigator who developed the planning techniques. In some cases the techniques are highly theoretical and non-operational, and thus hard to grasp by management. Aware of this crucial fact, management consultants have developed simulation models for the administrators which "communicate" the need to view university development as a comprehensive whole. RAPID is one such model.

It presents a set of methodological steps and techniques purposely intended to inform university and college management planners and faculty of the various component elements and tools of institutional planning. Other efforts to "communicate" the rather sophisticated techniques such as CAMPUS are being made by their authors by adjusting the model to meet the needs of higher education.

Most of the techniques discussed in this study were initially developed for defense purposes within the realm of economics, and, only later transferred to university planning. To be effective, spinoffs from other areas of research (where these techniques were successfully developed) can only be applied by establishing the preconditions within university management which are conducive to the understanding, acceptance, and implementation of these techniques. What are some of these preconditions?

There are no ready-made formulae which can turn a university manager into a corporation strategist overnight. However, as the institutional manager becomes sophisticated in the use of these techniques, their range of application, their limitations and constraints, a first vital step is taken toward the development of effective institutional management and planning techniques. The main objective of this study is to provide this kind of information.

Other management techniques, such as the planning programming budgeting system (PPBS) are currently being tested in several universities. The real value of these tests perhaps lies in the involvement through participation which they offer to management, administration, faculty, and students in university developmental planning. The tools for comprehensive university planning are available. If used sagaciously they can prevent major blunders in resource allocation and indicate avenues for effective management.

Institutions lacking the manpower necessary to implement these techniques can pool their resources in a cooperative effort through a consortium of institutions as in the cases of WICHE and PMM'S SEARCH. This alternative can provide the necessary manpower inputs to analytical studies as simulation models or management information systems. Since the total planning effort is a function of management, its implementation will however have to lie solely within the province of the individual institution.

If these techniques are to be successfully integrated into the instutitional planning process, the establishment of the socio-technological preconditions for the understanding acceptance and effective implementation of these tools is essential. The dynamics of institutional behavior and the sociological aspects of college and university management is a broad, pervasive, and engaging issue that certainly extends beyond the scope of this study and into the realm of the behavioral sciences. However, the crucial role that this aspect of institutional management plays in the successful implementation of the techniques discussed here merits the careful consideration of both institutional researchers who are developing new analytical and forecasting techniques as well as the institutional managers who would in the final analysis have to utilize them.

This study provides both a critical survey of available techniques as well as a conceptual framework for an understanding of the dynamics of interaction of the various component elements of an institutional system.

When reviewing the shelf of available planning tools offered in this study, university administrators will have to carefully assess the possible avenues of transferability and devise adequate strategies for implementation in the light of the peculiar requirements and resources of their own institutions.